This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

NYPL RESEARCH LIBRARIES
3 3433 07597651 8

THE PREVENTION
OF
INDUSTRIAL ACCIDENTS

No. 1
General

THE FIDELITY AND CASUALTY
COMPANY OF NEW YORK

THE FIDELITY AND CASUALTY COMPANY

OF NEW YORK

92 - 94 LIBERTY STREET AND
97 - 103 CEDAR STREET, NEW YORK

OFFICERS

GEORGE F. SEWARD	President
ROBERT J. HILLAS	Vice-President and Secretary
HENRY CROSSLEY	Assistant Secretary
FRANK E. LAW	2d Assistant Secretary
GEORGE W. ALLEN	3d Assistant Secretary

DIRECTORS

DUMONT CLARKE	Pres. Am. Ex. Nat. Bank
WILLIAM P. DIXON	Counsellor-at-Law
ALFRED W. HOYT	Merchan
GEORGE E. IDE	Pres. Home Life Ins. C
WILLIAM G. LOW	Counsellor-at-La
FRANK LYMAN	Trustee United States Trust Co
JOHN G. McCULLOUGH	Erie Railroad Co
WILLIAM J. MATHESON	Merchan
ALEXANDER E. ORR	Retired Merchan
HENRY E. PIERREPONT	Retired Merchan
ANTON A. RAVEN	Pres. Atlantic Mutual Ins. Co
JOHN J. RIKER	Merchan
W. EMLEN ROOSEVELT	Banke
GEORGE F. SEWARD	Presiden

DEPARTMENT SUPERINTENDENTS

Fidelity	Edward C. Lun
Accident	Hedley R. Woodwar
Plate Glass	Allan J. Ferre
Liability	Theodore E. Ga
Boiler and Flywheel	William H. Boeh
Burglary	William P. Learne
Agency	Henry Crossle
City Liability	William J. Johns
Inspections	Daniel C. Harv
Claims	Arthur W. Parso
Counsel	Charles C. Nad
General Counsel	William G. Lo

Fidelity and Casualty Company of New York

THE PREVENTION OF INDUSTRIAL ACCIDENTS

No. 1—General Pamphlet

COMPLIMENTS OF

The Fidelity and Casualty Company

GEO. F. SEWARD, President

92 TO 94 LIBERTY STREET AND
97 TO 103 CEDAR STREET

NEW YORK CITY

Published by

THE FIDELITY AND CASUALTY COMPANY OF NEW YORK
92 to 94 LIBERTY STREET and
97 to 103 CEDAR STREET
NEW YORK

SEPTEMBER, 1909

NEW YORK PUBLIC LIBRARY

AF

Price, Twenty-five Cents

THE NEW YORK
PUBLIC LIBRARY
479726
ASTOR, LENOX AND
TILDEN FOUNDATIONS.
R 1910 L

Copyright, 1909, by The Fidelity and Casualty Company of New York
All rights reserved

RAND McNALLY & CO., NEW YORK

Dedication

This pamphlet is dedicated to our Policy-Holders in grateful appreciation of their abundant confidence in the Company, and in the hope that it will be found very useful to them.

It will be followed by other pamphlets in serial form devoted severally to specific industries.

THE FIDELITY AND CASUALTY COMPANY
OF NEW YORK

Note

How to prevent accidents has been a pressing question ever since the use of machinery began. But in spite of this, what has been published on the subject is quite unequal in quantity as regards the various appliances used, being plentiful as regards boilers and engines, scattering and occasional as regards elevators and factory and wood-working machinery, and meager as regards electrical apparatus. The consequence is that there has been abundant room for the collection of information at first hand. It is believed that this is the first attempt that has been made in this country to gather together in a systematic treatise what has been settled by experience with regard to the prevention of industrial accidents, and to present a measurably adequate and comprehensive treatment of this vital question.

The question of how to ensure safety of life and limb is one that enters necessarily into the design, material, construction, and operation of every appliance and structure in works. Obviously it has been impossible to discuss every appliance and structure because of the necessity of keeping the size of this pamphlet within reasonable limits. A judicious selection of material for treatment has therefore been made. That has been selected which it is believed will be of the most value to the average operator of works.

In preparing this pamphlet and the subsidiary pamphlets dealing with the conditions peculiar to given industries, the sources of information have been the records of the Fidelity and Casualty Company as regards injuries sustained by employees of its assured and others; the observations made in the course of its business by its inspectors of boilers, engines, flywheels, employers' liability risks, etc., and by the engineers and experts in charge of its underwriting and inspections; text-books; current publications; and manufacturers' descriptions of their safety devices. It has not been possible to give credit in every case for the information so obtained, but an effort has been made to do so wherever a direct quotation has been made. To all who have aided in the preparation of the pamphlet we extend our hearty thanks.

Table of Contents

PAGE

Introduction . . . . : . 1

Care on the Part of Employers and Employees 5

Safety Devices 9

Steam Boilers 10

Engines 58

Electrical Apparatus 90

Elevators 100

The Factory 131

Wood-Working Machinery 168

Index 186

Introduction

THE desirability of preventing accidents no one will question. Putting aside the humanitarian aspect of the matter which must appeal to every lover of his kind, the financial loss alone due to accidents is so great as to warrant the most complete precautions for their prevention. In the year 1908 the large sum of $22,392,072 was paid in premiums to insurance companies for liability insurance.

The prevention of accidents absolutely is of course impossible. But much more can be done to prevent accidents than at first sight appears.

Statistics regarding the causes of industrial accidents in the United States have not been collected except in fragmentary form. It is but lately in fact that much interest has been taken in the matter. This is perhaps not surprising as it is not long since the responsibility of the employer for the safety of his employees was brought home to him. Employers' Liability insurance to meet this increased responsibility is comparatively new in this country, having been first transacted in 1886, and only within the last few years having reached its present high development.

It is to Germany that we must turn for exact information regarding the causes of accidents. From statistics collected there in connection with Workmen's Compensation insurance, it appears that the greater number of accidents, 57.95 per cent., are due to the negligence of employers or employees, and the smaller number, 42.05 per cent., to the inevitable risks of employment. The causes of accidents are stated as follows:*

Inevitable risk	42.05	per cent.
Want of skill and carelessness	20.25	" "
Want of guards	7.82	" "
Deficient factory arrangements	7.15	" "
Acting against rules	5.44	" "

---

*The Workmen's Insurance of the German Empire, described for the St. Louis Universal Exposition, 1904, by the Imperial Insurance Office and the Imperial Statistical Office in Berlin, page 21, "The Causes of Accidents (question of fault)."

Fault of other (third) persons .	5.28	per cent.
Fault of employers and workmen	4.66	“ “
Not using guards	1.92	“ “
Insufficient instruction . .	1.84	“ “
Superior force, casualty, etc. . .	1.31	“ “
Carelessness	1.19	“ “
Unfit clothes	0.49	“ “

In considering these percentages, it should be borne in mind that the precautions for preventing industrial accidents are far and away more complete in Germany than in the United States. Under the administration of the Workmen's Compensation laws, the invention and use of safety devices are encouraged and the use of safety devices has consequently become very general. The United States not having progressed so far, it is probable that more than 57.95 per cent. of the accidents that occur are preventable.

Frederick L. Hoffman, writing on "Industrial Accidents" in the "Bulletin of the Bureau of Labor" (No. 78, September, 1908), of the United States Government, says:

"As stated at the outset, upon a conservative estimate, the total mortality from accidents in the United States among adult male wage-earners is between 30,000 and 35,000, of which it should not be impossible to save at least one-third and perhaps one-half by intelligent and rational methods of factory inspection, legislation, and control. In addition there were approximately not much less than two million non-fatal accidents, that not only involve a vast amount of human suffering and sorrow, but materially curtail the normal longevity among those exposed to the often needless risk of industrial casualties."

From the foregoing it is clear that a wide field exists for the prevention of industrial accidents. All accidents due to negligence are evidently preventable. The means of prevention lie in the direction, first, of proper design and construction of the plant and appliances; second, of care on the part of employers and employees; and third, of the use of safety devices.

Our business of liability insurance has led us to study these means by which industrial accidents may be prevented. In the following pages we have set down the results of our observations and studies. This pamphlet is restricted, however, to those precautions which are of general application in all industries. Other pamphlets have been prepared dealing with the conditions peculiar to given industries. These may be obtained from us.

Many of the recommendations made in this pamphlet may be carried out at small expense, and even where the expense is considerable, it is believed that it will pay for itself in the long run. If in some cases changes to conform to the recommendations are found too costly, it will be well to bear them in mind when making replacements and renewals. Dispositions may often be made then that would not be practicable at other times.

We shall be glad to aid whenever desired with advice and suggestions.

THE FIDELITY AND CASUALTY COMPANY
OF NEW YORK

New York, September, 1909

Care on the Part of Employers and Employees

Physical Surroundings Not only the safety of workmen, but the maximum output of the plant, are promoted by making the physical surroundings of the workmen as comfortable as possible. Plenty of light, good air, safety, and comfort pay in a financial sense.

Insufficient Lighting Statistics show that the greatest number of accidents occur during the months of diminishing light. Dirty windows and insufficient artificial illumination often make conditions much worse than they need be.

Great improvement in illumination may be had by whitewashing the walls of a dark room at least once a year. This also saves much on the cost of artificial illumination.

Overcrowding of Machinery Considerations of economy often lead to the overcrowding of machinery, that is, too many machines are placed in a given space. The width of the passageways between the machines is thus reduced to the point of danger. Any undue curtailment of space interferes with the proper handling of the machines and adds to the risk and probability of accident, owing to the operator being exposed to contact with gears, pulleys, belts, and other moving parts, for even where guards are provided in fullest measure, it is rarely possible to eliminate absolutely all danger. Space should not be held of more value than safety.

Slippery Floors Slippery floors constitute an element of danger, especially in conjunction with unguarded machinery. And even where a slippery floor is not in proximity to an unguarded machine, it may yet cause a bad fall, resulting in serious injuries. This is likely to be the case where workmen are engaged in carrying heavy material.

Ignorance Many accidents, and very often those of a serious nature, are due to the ignorance of the workmen. New hands are put to work on dangerous machines without proper preliminary training or sufficient instructions. Even where apprenticeship is not necessary or customary, new hands should nevertheless work with and under the instruction of experienced hands until there can be no question of their competency. All workmen should be carefully instructed, in language they can understand, the proper and safe way to do their work.

Especial care should be exercised in the case of minors employed as operatives on dangerous machines. Some machines are too dangerous ever to allow a young person to operate them. The monotonous nature of the work, so contrary to the natural active propensities of the young, will lead to a moment of thoughtlessness in the operator, and that to a grave accident.

Carelessness The importance of this feature cannot be overestimated. In Germany* "out of 45,971 accidents noted in the industrial accident statistics for 1897, there were 9,363 caused by the 'improvidence or inattention of the workmen,' 533 cases by 'frivolous behavior,' 2,422 cases by 'acting in contradiction to instructions,' 861 cases on account of 'non-use of existing devices for protection,' and 220 cases by 'unsuitable clothing.'" Probably in the case of American workmen the consequences of lack of discipline are an even more prolific source of accidents.

Under the conditions the employer is warranted in making strict rules governing the employees in his plant. In fact, it is his duty to do so. By the maintenance of discipline, to which punitive measures are added where necessary, many accidents may be prevented. Disobedience of orders should not be tolerated.

Unsuitable Clothing Ragged sleeve ends, loose cravats, and coats or overalls not properly buttoned, often catch on moving parts of machinery and cause serious and fatal accidents. It is a wise precaution in many classes of work to roll the sleeves of all garments up above the elbows. Female operatives with flowing hair or loose braids are constantly in danger from moving belts and spindles and revolving shafts. They should be required to wear the hair as close to the head as possible. The working dress of females should be as close-fitting and simple as is practicable. Flowing sleeves and long apron strings are especially to be avoided.

---

* The German Workmen's Insurance as a Social Institution, Exposition at St. Louis, 1904, Part III, Prevention of Accidents and Workmen's Hygiene, page 7.

Failure to Use Safeguards Provided Very often workmen will object to the use of safeguards provided, claiming that they interfere with quantity of output and so cut down their earnings. This is likely to be the case particularly with piece-work. By the exercise of a little ingenuity, however, the guard may often be adapted to perform its function and yet not interfere with the speed of the work. No guard should be condemned simply because the workmen at the outset object to its use. Rather this should lead to further study of the matter and modification of the guard to suit the conditions.

Overwork Fatigue leads to carelessness, and long hours of labor without rest are responsible for many accidents. Overworking workmen should be avoided wherever possible.

Ventilation A continuous supply of pure air is no doubt of greater importance from the standpoint of maintenance of health than it is from the standpoint of prevention of accident, but the two are related. Whatever lowers the vitality of the workman, decreases his alertness and watchfulness to avoid accident. Impure air, gases, vapors, dust, and smoke therefore all increase the chances of accident, in addition to imperiling the health of workmen.

Intoxicants Wherever possible, it is advisable to prohibit absolutely the drinking of intoxicants during working hours. No man under the influence of liquor, even slightly so, should be permitted to remain in the works, much less to work. Nor should a man whose nerves have been rendered unsteady by the habitual use of alcohol or by a recent debauch be permitted to operate dangerous machinery, or to carry on dangerous work. He endangers not only his own life, but also the lives of others.

Supervision and Management Whether accidents are frequent or infrequent will depend in no small measure upon the character of the supervision and management. If those in positions of authority are careful and prudent, their conduct will be reflected in the conduct of the workmen, who will tend to be careful and prudent also. Unconscious imitation is one of the strongest forces that mold men. Imitation grows into habit. Managers, superintendents, foremen, and others in authority then, should be persons of experience and given to exercising a high degree of care in all that they do. The utmost care should be taken in selecting them.

Rules The education of the workmen in proper and safe practices will be promoted by the posting of printed rules regarding the things they should avoid doing, and the precautions they should take to avoid accidents. In the case of especially dangerous machines, it is advisable to furnish the operatives with special rules and instructions relative to their operation. It is also particularly important to warn workmen of dangers not apparent except to experienced and intelligent men, and to show them how such dangers may be avoided.

Inspections Regular and frequent inspections by competent men should be made of all the ways, works, machinery, and appliances, so that defects and unsafe conditions may be discovered promptly and remedied.

Further Care The further care and precautions requisite to be taken for the prevention of accidents are set forth in the subsequent chapters, along with the description of the proper design and construction of various appliances used in industrial works, of the safety devices regarded by us as suitable and efficient, and of the use of such devices.

Safety Devices

Safety Devices Nothing of course is a complete substitute for alertness and watchfulness in operating dangerous machinery, nevertheless there are numerous safety devices that are efficient aids in the prevention of accidents. The expense of many of these devices is but trifling in comparison with the security they afford. And even where the expense is considerable, they will as a rule be found to pay for themselves in the long run.

The safety devices treated of are grouped under the following heads:

Steam Boilers
Engines
Electrical Apparatus
Elevators
The Factory
Wood-Working Machinery.

It has been deemed best, for various reasons, not to name the makers of the various safety devices described and illustrated. The name and address of such makers, where the devices are on the market, will, however, be cheerfully furnished on application. Our preference is to name the makers of all devices suitable for a given purpose and let the applicant make his choice. Wherever possible, devices covered by patents have been indicated by foot-notes.

For other safety devices, see separate pamphlets dealing with conditions in special industries.

Steam Boilers

Boiler Explosions Boiler explosions are due either (a) to lack of sufficient strength to sustain the working pressure, or (b) to an increase of pressure beyond that which the boiler was designed to sustain.

The deficiency in working strength (a) may arise from defective design, from faulty construction including the use of inferior material and failure to follow the specifications, from deterioration of the structure due to use and lack of proper care, from mismanagement in the operation of the boiler, and from failure to make needed repairs. Scale, corrosion, defective workmanship, "burned" plates and overheated surfaces due to low water, cracks in the seams, and the weakening resulting from unequal expansion and contraction, are the most common sources of danger.

The stresses to which boilers are subjected in operation are very great. Adjacent parts often have different temperatures, which occur in raising steam or in blowing off under pressure, and these cause unequal expansion and contraction. Besides this, while actually at work, there are severe stresses set up by local contractions when the shell is chilled by pumping in cool feed-water. This constant tendency to distortion racks the boiler and causes leaking seams and cracked plates.

The excessive pressure (b) may be due either to the continued evaporation of water after the outlet of steam has been closed, or to the phenomenon known as "water-hammer." When the outlet for steam is stopped, the pressure gradually rises until the safety-valve opens, after which, if the opening has sufficient area, all the steam made will flow off, and no further rise of pressure will occur. But if the safety-valve sticks, or for other reason fails to act, the pressure will soon exceed the limit of safety. The rate of increase in pressure, after the safety-valve has become inoperative, may be calculated by the following formula, in which it is assumed that the rate of evaporation is constant:

$$T = W\frac{t - t_1}{Q}$$

in which

T = time, in minutes, which must elapse between the instant when all outflow of steam is stopped and the instant when a dangerous pressure is reached.

W = weight, in pounds, of water in the boiler.

t = temperature of water, in degrees Fahr., in the boiler at the dangerous pressure.

t_1 = temperature of water, in degrees Fahr., in the boiler at the instant the flow of steam is stopped.

Q = quantity of heat, in British thermal units, supplied by the furnace and absorbed by the water per minute.

The formula shows that the increase in pressure will be less rapid in the case of a boiler containing a relatively large amount of water and having a low rate of evaporation, as, for instance, a marine boiler; and more rapid in the case of a boiler containing a relatively small amount of water and having a high rate of evaporation, such as a locomotive boiler. Low water is thus proved to be dangerous, not only because it exposes the plates to overheating and "burning," but also because it causes a rapid increase in pressure due to the small amount of water then remaining in the boiler. The formula shows also that the increase in pressure will be more rapid at high pressures than at low pressures, since at high pressures there is a greater difference of pressure for equal changes of temperature than at low pressures (see any table of the properties of saturated steam, as, for instance, in "Kent's Mechanical Engineer's Pocket-Book").

As an illustration, suppose a horizontal tubular boiler having a grate-surface of 25.6 square feet, burning 12 pounds of coal per square foot of grate per hour, and carrying a working pressure of 150 pounds per square inch. Each pound of coal evaporates 9 pounds of water from and at 212° Fahr. A dangerous pressure is reached when the metal is stressed to its elastic limit. Suppose that this dangerous pressure is 335 pounds per square inch. How soon would this dangerous pressure of 335 pounds be reached, assuming that the boiler contained 9,984 pounds of water and that the evaporation of each pound of water required the expenditure of 965.7 thermal units?

The coal burned would evaporate 25.6 × 12 × 9 = 2,764.8 pounds of water per hour, or 46 pounds per minute. From the table of the properties of steam, Kent's Pocket-Book, cited above, the temperature corresponding to the working pressure is, $t_1 = 365.7$, and that corresponding to a dangerous pressure, $t = 432.0$.

Then

$$T = W \frac{t - t_1}{Q}$$

$$= 9{,}984 \times \frac{432.0 - 365.7}{46 \times 965.7}$$

$$= 15 \text{ minutes approximately.}$$

Opening the stop-valve suddenly, or the bursting of the main steam-pipe or an elbow or a tee in it, may give rise to "water-hammer." To understand this phenomenon, it is necessary to note, first, that water boils when the tension of its vapor equals the pressure to which it is subjected; second, that the higher the pressure the higher is the temperature of the water when it boils; third, that the higher the temperature the more heat does the water contain; and fourth, that any diminution of pressure on boiling water will release a quantity of heat that will expend itself in evaporating a considerable percentage of the water. An example will make this clear. Suppose a boiler is making steam of 150 pounds pressure. Each pound of water at this pressure contains 338.4 heat units above 32° Fahr. Suppose now that by the blowing-out of the shell man-hole plate in the steam space, the pressure is suddenly released and falls to atmospheric pressure. To maintain the water at the boiling-point at atmospheric pressure requires only 180.9 heat units above 32° Fahr. in each pound of water. There are therefore released $338.4 - 180.9 = 157.5$ heat units. These heat units will be expended in evaporating part of the water, and as the latent heat of steam, or heat of vaporization, at atmospheric pressure is 965.7 heat units, $157.5 \div 965.7 = 16$ per cent., or about one-sixth, of the water will flash into steam. This steam, diffused throughout the water and suddenly expanding, will project the remaining 84 per cent. of the water with great violence against the shell, and the impact will often be sufficient to burst the boiler and hurl its fragments far and wide.

The explosion of a boiler is not an instantaneous action, but a series of well-defined but rapidly succeeding operations. If the break occurs below the water-line, it is possible that no explosion will ensue, as the situation of the break is not favorable for the production of "water-hammer," and the boiler will relieve itself of its pressure by the water issuing out first. But if the break be above or near the water-line, the circumstances are favorable to the production of "water-hammer," and a violent explosion may occur. The method of explosion in most instances seems to be the opening of a small orifice at a point where the resistance offered by the material is less than the stress to which it is subjected, followed by an outrush of steam or water, or both; the extension of the rupture to the adjoining parts when these parts become too weak to sustain the increased stress which the break already made puts upon them, this operation being so sudden that sufficient time is not allowed for the gradual escape of the enclosed fluids; and the boiler is torn violently into fragments and distributed far and wide by the steam generated from the liberated water. An explosion does not ensue if the parts adjacent to the initial rupture possess sufficient strength, and it is probable that explosions do not occur unless the strength of the boiler is quite uniform, but less than that required to sustain the pressure. Local weakness is a safety-valve that permits a rupture and ensures against a general disruption. Minor defects surrounded by strong parts merely relieve the pressure, but a long seam weakened by corrosion or "burning" of the lap, a considerable area of plate thinned by corrosion or weakened by overheating, or an extended crack, may be the occasion of a disastrous explosion.

The energy in a cubic foot of highly heated water is equal to the energy in a pound of gunpowder. Most of the energy in a steam boiler under pressure is contained in the water and only a relatively small amount of the energy in the steam. Take, for instance, the case of a horizontal tubular boiler carrying 150 pounds pressure and having 160 cubic feet of water space and 80 cubic feet of steam space. The water weighs 160 × 62.4 =

9,984 pounds, and the steam weighs 80 × .3671 = 29.37 pounds. The energy in each pound of water at 150 pounds pressure that would be liberated by explosion and expansion down to 212° Fahr. is 11,823.4 foot-pounds, and the energy in each pound of steam at the same pressure is 134,521.2 foot-pounds ("A Manual of Steam Boilers," by Professor R. H. Thurston, table entitled "Total Available Energy In Water And Steam"). The total energy in the water is therefore 9,984 × 11,823 = 118,040,832 foot-pounds, and the total energy in the steam is 29.37 × 134,521 = 3,950,882 foot-pounds. The energy in the steam is consequently less than four per cent. of that in the water. The water is the more dangerous content of the boiler. The total energy in the water and steam is 118,040,832 + 3,950,882 = 121,991,714 foot-pounds. If the boiler weighs, say, 10,000 pounds, and if all of this energy were expended in an explosion in projecting the boiler vertically, then, neglecting the friction of the air, the boiler would rise to a height of 12,199 feet, or over two miles.

The secret of avoiding boiler explosions is regular inspections at short intervals by competent men, and prompt compliance with their recommendations in regard to repairs and the allowable working pressure. Professor Thurston concluded that but one boiler in ten thousand explodes among those that are insured and periodically inspected, and that the proportion is ten times as great among those uninsured and uninspected.

Boiler-Room The prevention of boiler explosions, no less than of the slighter accidents, such as ruptures, collapses, bursting of pipes, etc., by which the attendants are seriously, if not fatally, scalded, depends upon the proper design, construction, and operation of the steam plant throughout. In order to ensure proper design and construction, the best procedure is to have the plant erected under the supervision of a capable mechanical engineer. Where the size of the plant will not warrant this expense, the next best thing is to submit the boiler design for approval to a boiler insurance company and to have the boiler inspected and approved by it before acceptance. The Fidelity and Casualty Company will undertake the examination of boiler specifications, or will on request furnish specifications for any desired boiler. Plans for boiler settings will also be furnished.

Material The specifications of material for the shell and heads of an externally-fired horizontal tubular boiler should include the following:

All materials used in the construction of the boiler to be the best of their respective kinds, and to be carefully inspected, any parts having mechanical defects to be rejected. Defects developed in working to cause the rejection of the defective part. The shell and butt-strap plates to be of open-hearth fire-box steel; the heads of open-hearth flange steel.

The metal to have the following properties: Tensile strength, 55,000 to 62,000 pounds per square inch of section; elongation, not less than 25 per cent. in 8 inches; elastic limit, not less than one-half of ultimate strength; cold bending test, coupon to bend flat on itself without fracture; quenching test, coupon to be heated to cherry red, cooled in water 82° Fahr., and to bend around a mandrel 1½ times thickness of plate without fracture. One coupon cut from each plate entering into the construction of the boilers to be subjected to these tests. Coupons to be stamped with numbers corresponding with the plates from which they are taken, and the test pieces to be shaped to form shown in the following diagram (Fig. 1). Mill test sheet of each plate in boiler to be furnished. Each plate must show the mill stamp plainly after boiler is built. Above includes butt-straps. Butt-straps to be properly rolled to required curvature.

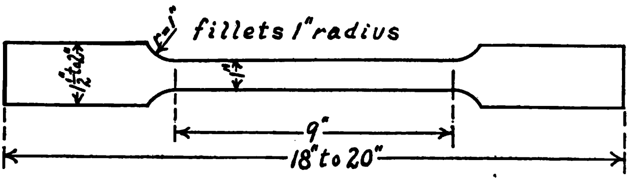


FIG. 1. TEST SPECIMEN

Plates exposed to the fire should be as thin as possible; they should never be more than one-half inch thick.

In the case of parts of the boiler where the exact determination of the stresses is difficult or impossible, as, for instance, the reinforcing rings placed around manholes, or where there are irregular stresses due to unequal expansion or where corrosion is likely to occur, as, for instance, the braces or stays, it is wise not to be economical in the use of material. Economy then is dangerous.

Longitudinal Seams of Boiler Shells The longitudinal seams of most horizontal tubular boilers have been for the most part, until very recently, of the double-riveted lap-joint type. This joint unfortunately is likely to develop a very serious defect. In the first place, the plate is often subjected to rough usage at the joint in making the boiler, and in the second place, the departure from circularity necessitated by the lapping-over of the plate at the joint introduces a dangerous bending action as the metal expands and contracts under the influence of changing temperature. From these causes a hidden crack between or parallel to the rows of rivets may develop sooner or later. If not discovered in time, a disastrous explosion may result. In boilers already constructed with this type of joint, safety lies in frequent inspections, and whenever a hidden crack is suspected, in cutting out the rivets and parting the plates at the joint for careful examination.

In new boilers it is advisable to substitute a triple-riveted or quadruple-riveted double-strapped butt-joint for the double-riveted lap-joint. The butt-joint forms a true arc of a circle and in consequence is not subjected to bending action. It is therefore far and away safer than the lap-joint. The inferiority of the lap-joint to the butt-joint is so palpable that in our opinion it should never be used. The longitudinal seams of the shells of steam-drums should also be constructed with butt-strapped joints.

There is another reason why the butt-joint is preferable to the lap-joint. This is a day of high and increasing steam pressures. Stronger boilers are required. A butt-joint has a much higher efficiency than a lap-joint, in general in the ratio of 85 to 70. The cost of the butt-joint, moreover, is but little greater than the lap-joint.

Strength of Boilers In calculating the strength of a boiler, the efficiency of the joint in the seam should always be taken into consideration. Joints vary greatly in strength according to the design. In general, the tensile strength of the metal left between the rivet-holes should equal the shearing strength of the rivets. The preferred rule for calculating the strength of a cylindrical shell transversely, that is, across a diameter, is as follows:

$$P = \frac{2Tt}{d} \times \frac{E}{F}$$

in which

P = safe working pressure in lbs. per sq. in.

T = ultimate tensile strength of metal in lbs. per sq. in.[*]

t = least thickness of metal in shell in inches.

d = diameter of shell in inches (the inside diameter of the outside course).

E = efficiency of joint.

F = factor of safety.

And the rule for calculating the strength of a cylindrical shell longitudinally is:

$$P = \frac{4Tt}{d} \times \frac{E}{F}$$

in which the symbols are the same as in the preceding formula.

These two formulæ show why it is not necessary as a rule for the circular seams of cylindrical shells to be more than single-riveted. The relations between the pressure to be resisted and the metal resisting the pressure are such that the longitudinal stress per unit of section is only half as great as the peripheral stress per unit of section. For the boiler to be equally strong in both directions, therefore, the efficiency of the joint in the circular seam need be only half as great as the efficiency of the joint in the longitudinal seam.

In the simplest form of joint, the single-riveted lap-joint, the formulæ of most importance for determining the efficiency of the joint are:

---

[*] The value of T used should be the lowest tensile strength stamped on the plates by the plate manufacturer. When the tensile strength of steel or wrought-iron shell plates is *not* known, the value of T taken should be 55,000 lbs. for steel and 45,000 lbs. for wrought-iron.

$$E = \frac{p-d}{p} \qquad (1)$$

$$E = \frac{ANS}{ptT} \qquad (2)$$

in which

E = efficiency of joint, stated as a percentage of the solid metal in the plate.

p = pitch of rivets in inches.

d = diameter of rivet-hole in inches.

A = area of rivet after driving, in square inches.‡

N = number of rivets in unit-section of joint.*

S = shearing strength of metal in rivets in lbs. per sq. in. of section.†

---

* In lap-joints the rivets are in single shear, but in certain sections of butt-strapped joints the rivets are in double shear. The cases must be distinguished.

† The maximum shearing strength of rivets per square inch of cross-sectional area should be taken as follows:

Iron rivets in single shear	38,000 lbs. per sq. in.
" " " double "	70,000 " " "
Steel " " single "	42,000 " " "
" " " double "	78,000 " " "

A rivet in double shear is not worth twice as much as a rivet in single shear but in general 1.85 times as much.

The following table gives the allowable shearing strength of rivets from 11/16 to 1 1/16 inches in diameter, in pounds:

Diameter of Rivet after Driving	11/16″	3/4″	13/16″	7/8″	15/16″	1 1/16″
Iron, single shear................	14,106	16,788	19,703	22,849	26,231	33.691
Steel, single shear...............	15,590	18,557	21,777	25,255	28,993	37,237
Iron, double shear...............	25,984	30,926	36,295	42,091	48,321	62,062
Steel, double shear..............	28,954	34,460	40,443	46,901	53,843	69,155

‡ When the diameter of the rivet-holes in the longitudinal joints of a boiler is *not* known, the diameter and cross-sectional area of rivets, after driving, should be taken as follows:

Thickness of plate....	1/4″	9/32″	5/16″	11/32″	3/8″
Diameter of rivet after driving................	11/16″	11/16″	3/4″	3/4″	3/4″ to 2″ pitch inc.
Cross-sectional area of rivet after driving	.3712 sq.in.	.3712 sq.in.	.4418 sq.in.	.4418 sq.in.	.4418 sq.in.

Thickness of plate................	3/8″	13/32″	7/16″	7/16″
Diameter of rivet after driving..	13/16″ over 2″ pitch	13/16″	7/8″ to 2¼″ pitch inc.	15/16″ over 2 1/4″ pitch
Cross-sectional area of rivet after driving......................	.5185 sq.in.	.5185 sq.in.	.6013 sq.in.	.6903 sq.in.

Thickness of plate................	15/32″	1/2″	9/16″	5/8″
Diameter of rivet after driving..	15/16″	15/16″	1 1/16″	1 1/16″
Cross-sectional area of rivet after driving.	.6903 sq.in.	.6903 sq.in.	.8866 sq. in.	.8866 sq.in.

These values are taken from the "Rules Formulated by The Board of Boiler Rules," State of Massachusetts.

t - least thickness of metal in plate in inches.

T - tensile strength of metal in plate in lbs. per sq. in. of section.

Formula (1) will then give the efficiency of the plate through the rivet-holes in the joint, and formula (2) will give the efficiency of the rivets in the joint in shear. Whichever formula yields the lower value of E will be used. In the best design of joint, barring modifications necessary to produce a joint in which the rivets are not too far apart for proper calking of the joint, there will be equality of value between efficiency of plate-section through the rivet-holes and efficiency of rivet-section. In more complicated joints, the formulæ will be varied to take into account all of the various features of the design. A separate calculation will be made for each of the ways in which failure of the joint may occur.

The value given to F, the factor of safety, will depend upon a variety of circumstances,—the age of the boiler, its condition, and the conditions under which it is worked. In a new boiler that is watched carefully a factor of safety of 4 may rarely be used, but 4½ to 5 is far and away better and affords greater security. As the boiler ages and deteriorates, the factor of safety must be increased. Just what factor of safety should be used at any particular time is a question that had best be left to the expert boiler inspector.

In our opinion, it is inadvisable to build externally-fired boilers over seventy-eight (78) inches in diameter.

Rivet-Holes Rivet-holes may be either drilled or punched, but if the latter method is employed the holes should be punched one-quarter (¼) inch below size with a spiral punch and reamed to size. The burr at the edge of the holes should be removed. No drift-pins should be used in the construction of the boiler; if necessary to "fair up" holes, a reamer should be used. Rivets should be machine-driven wherever possible. The distance from the center of the rivet-hole to the edge of the plate should not be less than one and one-half (1½) times the diameter of the rivet-hole in order that the plate in front of the rivets shall not crush and cause the joint to fail.

Circulation of Water It is of the utmost importance to design a boiler so that free circulation of water will be attained. Constricted passages are sometimes found in water-tube boilers that interfere seriously with the circulation.

In horizontal tubular boilers, the tubes should be set in vertical and horizontal rows, with a space between them, vertically and horizontally, of not less than one inch. A space two inches wide should be provided between the center vertical rows of tubes. No tube should be nearer to the shell than three inches. The lower rows of tubes should be well up from the bottom of the boiler so as to have a good solid body of water for the heat from the furnace to act upon. By this arrangement of tubes, a good circulation of water will be obtained, and the boiler will be much more easily cleaned and maintained at its maximum efficiency. The tubes should never be staggered, either vertically or horizontally, as such arrangement will interfere seriously with the circulation.

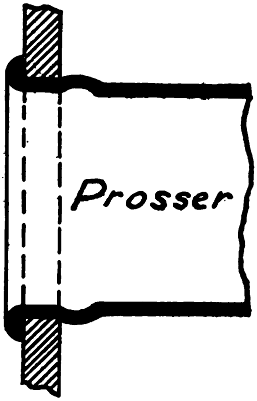


FIG. 2. EXPANDED TUBE

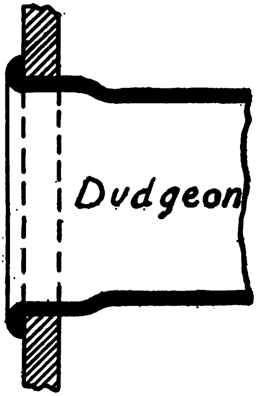


FIG. 3. EXPANDED TUBE

Setting Tubes The holes for the tubes through the heads or tube-sheets of boilers should be drilled and neatly chamfered off. In setting the tubes, either a Prosser wedge-expander or a Dudgeon roller-expander may be used, according to the conditions. Figs. 2 and 3 show the results accomplished by the two expanders together with the beading over of the ends of the tubes by a boot-tool. The Prosser expander makes a shoulder against the plate, while the Dudgeon expander simply rolls the periphery of the tube flat against the margin of the tube-hole. The tubes of boilers exert considerable holding power and act as braces or struts. Tubes that are in tension only may be set with a Dudgeon expander, but it is well to set tubes that are subjected to compressive stresses with a Prosser expander or else with a special roller-expander in which the rollers are shaped to form a shoulder in the tube against the plate. After setting the tubes in *water-tube* boilers, —they should be set to project a quarter of an inch beyond the plate,—the ends of the tubes should be flared slightly by a special tool provided for the purpose. Flaring the tubes thus will give ample holding power. After setting the tubes in *fire-tube* boilers, the ends of the tubes should be beaded over with a boot-tool, the work being done in a careful manner to avoid fraying and splitting the metal. In our opinion, this beading over of the ends of fire-tubes is absolutely necessary. By far the greater number of boilers are fired with soft coal, and if the ends of the tubes are simply flared, soot will accumulate in the recess around and under the end of the tube, and the ends of the tubes will soon burn or corrode off. When the end of the tube is beaded over, there is no recess in which the soot can accumulate. In using a Prosser expander, care must be taken not to use one too small for the particular thickness of tube-sheet into which the tubes are being expanded, else the tube will be squeezed thin at the junction of the shoulder with the plate and will soon give way.

Domes vs. Dry-Pipes

A dry-pipe is quite as efficient as a dome in providing dry steam for a stationary boiler. There is no sense therefore in weakening a boiler by putting a dome on it. If more steam space is required than is provided by the steam space of the boiler, a steam-drum may be used to advantage in lieu of a dome. But in case a dome is put on, the hole in the shell of the boiler leading to the dome should not be cut the full size of the dome, but only the size of a man-hole. Reinforcing rings at the man-hole equivalent to the metal cut away should be provided in order that there may be no loss of strength. The dome should be double-riveted to the shell. If the hole in the shell of the boiler leading to the dome is cut out the full size of the dome, as is usually done in locomotive boilers, the boiler is weakened greatly, and a special form of construction should be adopted to reinforce the opening. One method is to flange down the cylindrical shell of the dome on to the shell of the boiler and flange up the shell of the boiler into the dome, double-riveting the flanges together and supplying a reinforcing ring around the opening, riveted to the inside of the shell. Another, and a better method probably, is to put on a flanged reinforcing collar between the shell of the boiler and the dome, in which case the shell of the boiler will not be flanged up.

Man-Holes In the case of horizontal tubular and marine boilers, man-holes should be provided both above and below the tubes to admit of thorough inspection. The man-hole below the tubes is sometimes omitted, but it is just as important that the lower part of the boiler be inspected as the upper. In the absence of the lower man-hole, dangerous defects may pass undetected. The lower man-hole also facilitates proper cleaning. In horizontal tubular boilers it is best to place the man-hole above the tubes in the shell, and the man-hole below the tubes in the front head. The man-hole in the shell should be cut with the long diameter girthwise. The proper size of a man-hole is eleven (11) by fifteen (15) inches. This will admit of easy entrance.

The man-hole in the head of the boiler should be flanged inward, a one-half inch ring shrunk on to give ample seat for the gasket, and the surface planed off to give a good bearing surface. The man-hole in the shell of the boiler should be provided with a cast-steel or wrought-steel frame, preferably of the "inside" type, and should be double-riveted to the shell. The underlying principle governing the reinforcement of man-hole openings is that the reinforcement provided shall be at least equal in strength to the metal that has been cut out in forming the man-holes. The man-hole plates should be of cast-steel or wrought-steel and of ample strength. Cast-iron man-hole frames should never be used.

The stock-holes of rotary boilers should be reinforced with wrought-steel rings. These reinforcing rings should be equal in strength to the metal cut away. Two rings of suitable width, thickness, and quality, one placed inside and the other outside, and riveted with two or three rows of rivets had best be used. Cast-iron rings should never be used; cast-iron is too uncertain a material under tension to be used for this purpose. The importance of reinforcing the stock-holes of rotaries thus is manifest on recalling that rotaries not only have to sustain the steam pressure, but also the weight and impact of the shifting material under treatment, and the blows from the pulpy mass are often serious.

The mouth-pieces of digesters, rendering tanks, bleachers, etc., should receive careful attention in designing. Wherever possible, cast-steel should be used instead of cast-iron. The flanges should be made abundantly thick, and brackets running from the flanges to the body of the casting at frequent intervals should be provided.

Hand-Holes In horizontal tubular boilers, if there is a man-hole in the front head under the tubes, there is no necessity for a hand-hole in the rear head. A hand-hole under such conditions is a source of unnecessary trouble. But where the boiler is too small for a man-hole in the front head under the tubes, there should be hand-holes in both the front and rear heads under the tubes, to facilitate cleaning.

In vertical tubular boilers, it is important to provide hand-holes in the shell, both at the level of the lower tube-sheet and in the water-leg, to enable the boiler to be properly cleaned. There should be at least four hand-holes located as follows:

One in the shell at or about the level of the lower tube-sheet.

One in the shell at or about the level of the fusible-plug, except where there is a man-hole in the shell or head through which the fusible-plug is accessible.

Two in the shell on opposite sides of the boiler and at the lower part of the water-leg.

A boiler of the locomotive type should have not less than six hand-holes located as follows:

One in the rear head below the tubes.

One in the front head at or about the level of the crown-sheet.

Four in the lower part of the water-leg, two on each side.

Also, wherever possible, one near the throat-sheet.

The best form of hand-hole guard is the common two-legged guard. It is better to have these guards too heavy than too light, as they will then be less liable to injury from burning.

Boiler Braces In bracing the heads of horizontal tubular boilers, the following is the best practice: The parts of the heads above the tubes are braced to the shell by diagonal braces set in radial planes. These diagonal braces should be of the weldless type, made of the best flange steel, all solid "crowfoot" braces, and secured at each end by two rivets. The braces should be as long as convenient in order to get as straight a pull as possible. The parts of the heads below the tubes should be braced with through-braces of the rod type, extending from head to head, and secured to the rear head of the boiler, by means of a turned pin and nut, on a "crowfoot" riveted to the head, while the end of the brace at the front head should be upset, threaded, and secured to the head by hexagonal nuts, one on the outside and the other on the inside of the head. The rear head, in addition to the through-braces, should be braced with a sufficient number of "crowfoot" braces, placed so that they come well up on the sides of the shell. Care should be taken to keep the through-braces tight. "Crowfoot" braces should never be used on the portion of the front head under the tubes. When brought down from the head on to the fire-sheet, scale will accumulate about the foot of the brace, and cause the sheet to crack by overheating.

In general, the maximum allowable stress per square inch of section of braces is 7,500 pounds. In some places, the law will not allow a stress in excess of 6,000 pounds.

Exposure of Seams to Fire The circular seams of horizontal tubular boilers should lap away from the fire. The horizontal seams should be kept away from the fire and above the fire line. The fire line should be level with lower surface of top row of tubes.

Calking The seams of boilers should be planed or beveled by machine before the shells are put together. All calking should be done with a round-nosed calking tool to avoid injuring the plates by scoring them. A sharp calking tool should never be used.

Stay-Bolts The stay-bolts in the water-legs of vertical tubular and locomotive tubular boilers should be drilled axially from end to end. The drip will give warning of a broken bolt.

It is well to turn down the central portion of stay-bolts to a smaller diameter than the ends, so that any bending that takes place will be distributed over the entire length of the bolt instead of being concentrated at the ends.

Flanges The flanges for the safety-valve and the main steam-pipe should not be less than one-half (½) inch thick. The flange for the bottom blow-off pipe should not be less than seven-sixteenths (7/16) of an inch thick. Lips of steam-pipe flanges should be two (2) inches deep at the threads, and of blow-off flange one and one-half (1½) inches deep. The threads on the pipes should be good for these dimensions. Whenever they are obtainable, drop-forged flanges should be used.

Safety-Valves It is of the utmost importance that the safety-valve shall be large enough to free the boiler of all the steam it can make, and that the valve be kept clear and in good working order. Two valves are better than one, though not absolutely necessary. When, however, the quantity of steam made is so large as to demand large discharging capacity, two small valves should be used rather than one large one. Under no circumstances should any additional weights be attached to safety-valves, dampers, or regulators. Safety-valves are liable to stick and should be lifted from their seats at least once a day. The pressure at which safety-valves blow off should be ascertained by raising the steam pressure till the safety-valve "simmers."

When an escape-pipe is used, it should be full-sized and fitted with an open drain to prevent water lodging in the upper part of the safety-valve or in the escape-pipe. When an elbow is placed on a safety-valve escape-pipe it should be located close to the safety-valve outlet, or the escape-pipe should be securely anchored and supported. There should be no stop-valve in the escape-pipe.

Occasionally boilers in office buildings, hotels, and apartment houses, in cities and towns, are equipped with "pilot"-valves. These are small safety-valves, attached to the boilers, and set to blow off at a pressure two or three pounds lower than the main safety-valves are set to blow off. They thus give warning of the approach of the steam pressure in the boilers to the blowing-off pressure of the main valves. By manipulation of the draughts, or throwing fresh fuel on the fire, or turning on the feed-water, the blowing-off of the main safety-valves may be prevented and the loud noise made by the valves avoided. This is an object in crowded buildings where many people may not only be annoyed, but frightened, by the loud noise made by the blowing-off of pop-valves.

The use of these "pilot"-valves is open to the objection that they may cause the main safety-valves to be neglected. Where the main safety-valves themselves blow off, they are more likely to get the proper attention. It is important therefore to give double attention to the main safety-valves where "pilot"-valves are used.

Stop-Valves Under no circumstances should a stop-valve be permitted between the boiler and its safety-valve. The stop-valve may be closed accidentally and make the safety-valve inoperative. Stop-valves should never be located in a position that will permit a head of water to accumulate on the seats when the boilers are idle. A stop-valve should never be opened or closed suddenly.

Provision should always be made for proper and safe access to valves. Too often large valves have to be manipulated at a considerable height above the ground and from a rickety ladder, where it would be quite practicable to arrange a permanent ladder and platform.

A prominent Michigan gas company has recently equipped its main boiler stop-valves with stems extending through the boiler-room wall into another room, so that in the event of a serious steam break in the boiler-room, the valves may be closed without danger.

The day of the single valve in each boiler connection is passing, wherever two or more boilers are connected to a common header. Many cities by ordinance now require two valves in each connection. To quote from "Power":

"The only argument in favor of the single valve is the lower first cost. Surely no one should be placed in jeopardy of such a horrible death as scalding in a boiler for the sake of the first cost of an extra stop-valve. Then boilers have been known to go for months in need of internal inspection and repairs, yet the work could not be done, nor could any cleaning be done, because the valve was leaking and no one could enter the boiler. Nor is the single valve with its usual leaks, calculated to inspire a man with the sense of complete security so vitally necessary if good work is to be done in a boiler."

Wherever two valves are adopted, it is recommended that one of them be an automatic boiler cut-off valve.

Automatic Boiler Cut-Off Valves It is often necessary, owing to some breakage, to close a stop-valve at a moment's notice. In many cases stop-valves are so placed that a ladder must be procured. Meanwhile the boiler-room is filling with steam. With an ordinary stop-valve, the fireman is frequently scalded in trying to shut off the main, or is driven from the boiler-room without being able to do anything to save the entire plant from shutdown. To avert such a catastrophe, the use of an automatic boiler cut-off valve (of which there are several types on the market) on the boiler steam-pipe is recommended wherever two or more boilers are connected to a common header. Such a valve should supplement, however, and not take the place of, the regular stop-valve. It should be placed between the regular stop-valve and the boiler outlet or nozzle, the nearer the boiler the better. Such a valve should preferably be of the double-acting rather than only of the non-return type, that is, it should protect the line as well as the boiler. Its purpose is, (1) to close automatically should a tube or any other part of the boiler give way, thereby isolating the disabled boiler from the others, or should a steam-pipe burst or a cylinder-head blow out; (2) to keep a boiler closed until its pressure equals that in the header, thus avoiding all accidents due to opening valves, either through carelessness or incorrect steam-gauges, while there is considerable difference of pressure; and (3) as an added protection to a man working in the boiler when cold. It will be noted that such a valve prevents the possibility of turning steam into a boiler in which a man is working,—the pressure in the header making it impossible to open the valve.

The check-disk in these valves is not attached to the valve-stem, but the valve can be used as an ordinary stop-valve by screwing the stem down until it holds the disk securely on its seat. The valve should be equipped with an outside lever or indicating device which will clearly show whether it is open or closed. The maker should guarantee the valve against chattering,—a fault to which some types are liable.

In France automatic cut-off valves have been compulsory since 1886, when the explosions of Eurville and Marnaval liberated steam which killed 30 people and seriously injured 60 others. In other European countries, such laws are now under consideration.

Fusible-Plugs and Low-Water Alarms Every boiler should be provided with either a fusible-plug or a high-and low-water alarm to guard against negligence on the part of the attendants.

Fusible-plugs should have a substantial brass casing and be filled with pure tin. The outside size should be not less than three-fourths (¾) of an inch pipe-tap, and the fusible metal not less than three-eighths (⅜) inch nor more than one-half (½) inch in diameter. The fusible metal should have the form of a frustum of a cone with the larger diameter toward the inside of the boiler to prevent it blowing out, and should be renewed at least once a year, or better still every six months, as its melting point tends to rise under the influence of continued heat.

Fusible-plugs should project through the sheet not less than one (1) inch and should be located as follows, the idea being to have them at the highest point of the metal that is exposed to the heat of the furnace:

(a) In Horizontal Return Tubular and Dry Back Scotch Type Boilers—in the rear head not less than two (2) inches above the upper row of tubes.

(b) In Scotch Marine Type Boilers—in combustion chamber top.

(c) In Horizontal Flue Boilers—in the rear head on a line with the highest part of the boiler exposed to the products of combustion.

(d) In Locomotive Type Boilers—in the highest part of the crown-sheet.

(e) In Vertical Fire-Tube Boilers—in an outside tube not less than one-third (⅓) the length of the tube above the lower tube-sheet.

(f) In Vertical Submerged-Tube Boilers—in the upper tube-sheet.

In Upright boilers or boilers of the Manning type, and in Water-Tube boilers, such as the Babcock and Wilcox, Stirling, Heine, Almy, Cahall, etc., it does not seem advisable, owing to their construction, to provide fusible-plugs.* With such types, and in other cases when a boiler has not a fusible-plug, a high- and low-water alarm should be placed on the water-column, preferably with no valves between the alarm and the boiler.

Both fusible-plugs and low-water alarms soon become useless unless well cared for. The former should be scraped bright every time the boiler is opened, and the latter tested every morning. Under no circumstances should a fusible-plug be replaced by a solid gas-plug. This has sometimes been done to avoid the bother attendant on the blowing-out of the alloy.

The low-water alarm should be set at the first gauge, and the high-water alarm at the third gauge, so that the fireman shall always have plenty of warning.

Low water is not nearly so often the cause of boiler explosions as is popularly supposed. But it is always dangerous and should be avoided. It is particularly to be avoided in the case of locomotive boilers, for the moment the water is off the crown-sheet, the sheet will soften in the intense heat and the stay-bolts pull through. Low water in any boiler may result in burning of the metal and consequent reduction of its strength. Burned metal, if not discovered, may result in a disastrous explosion.

---

* But it should be noted that in some places the law requires every boiler to be provided with a fusible-plug. This is the case in Massachusetts.

Steam-Gauges and Connections Every boiler should have its own steam-gauge. It is not uncommon to find boiler steam-gauges so faultily connected that they always show the line pressure. The piping to gauges should be as short and direct as possible, with no valves or stop-cocks other than the cock at the gauge. There should be a water pocket next to the gauge to prevent the steam from coming into contact with the bent tube and by its heat so altering the temper of the tube as to make the reading incorrect.

All pressure-gauges about a boiler plant should be tested regularly and kept properly adjusted, so that they will show the correct pressure. Frequently so little care is given the gauges that there will be only one or two fairly correct for a dozen boilers. It is an excellent idea always to compare the steam-gauge with the safety-valve when the latter blows off. If they do not agree, the fireman should ascertain which is incorrect.

Inequality of pressure, when cutting in boilers, due to lack of gauges or to incorrect gauges, may cause serious and costly accidents.

Blow-Off Pipes and Connections All boilers should be provided with a blow-off pipe at the bottom of the boiler to blow out scale and sediment. The cock to this pipe should be opened at least once a day and the accumulated sediment blown out. With good water, i. e., water that makes little scale, two (2) inch pipe should be used for the blow-off, but with bad water, i. e., water that makes much scale, two and one-half (2½) inch pipe should be used.

In the case of horizontal tubular boilers, a flange one-half (½) inch thick with a lip one and one-half (1½) inches deep should be riveted to the bottom of the boiler eight (8) inches from the rear head, and into this the vertical nipple of the blow-off pipe should be screwed, the threads on the pipe being made good for the entire thickness of the metal in the flange and sheet.

A bushing should never be used between the vertical nipple of the blow-off pipe and the boiler shell, nor should cast-iron bushings ever be used in any part of the blow-off connections. Cast-iron pads should be discarded as far as possible when making repairs and replaced by steel drop-forged flanges riveted to the shell, the vertical nipple to be well threaded into this forging. Vertical nipples should be at least twenty-four (24) inches long and preferably thirty (30), wherever possible, to lessen stress on pipe and to keep the horizontal section out of the flame. The hole through the rear wall should be large enough to permit free expansion of the pipe. The rear end of the boiler should be set one (1) inch to one and one-half (1½) inches lower than the front end, to facilitate drainage.

Use extra heavy pipe for blow-off connections, and use malleable-iron or steel fittings. Cast-iron fittings in these connections are dangerous. The use of crosses instead of elbows outside of the boiler setting is recommended, in order to permit of cleaning in both directions by simply removing the plugs in the blind ends. Do not use any reducers in blow-off connections. Renew any piping or fittings showing any signs of corrosion, as the bursting of blow-off pipes is a prolific source of serious, and often fatal, accidents. Do not use brass tubing for blow-off pipes on *externally*-fired boilers. Brass is not a safe material for such pipes; it softens and loses its strength at temperatures that do not affect iron.

The use of an ordinary globe- or gate-valve on the blow-off pipe is not good practice, as scale or other foreign matter will lodge on the seat and prevent the valve from closing properly. An asbestos-packed or other cock of similiar type is not subject to such interferences without betraying the conditions by its manner of working, and is therefore better. Or one of the regular blow-off valves now on the market may be used. The use of both is advantageous, in that it permits the one further from the boiler to be inspected without shutting down the boiler. Ordinary plug-cocks such as are used on water-pipes are unfit for blow-off pipes. The plug of a blow-off cock should be distinctly marked in line with its passage, and it is recommended that a spanner-guard be fitted to the cock to prevent the possibility of unshipping the box-spanner without closing the blow-off cock.

Blow-off valves must be kept tight and should be *known* to be tight. Leakage may be discovered by placing in the pipe just beyond the blow-off valve a tee with a one-inch outlet, to which a gate-valve is attached. The latter is left open except when blowing off and acts as a telltale if the blow-off is leaking. Another, but less reliable method, is to feel the blow-off waste-pipes at frequent intervals.

Blow-Off Pipe Protection In horizontal tubular boilers the blow-off pipe should always be protected from the flame in one of the following ways:

1st. Wrap the pipe from top to bottom with three-quarter inch asbestos rope.

2nd. Surround the pipe with a substantial cast-iron or fire-clay removable sleeve somewhat larger than the blow-off pipe. The space between may be filled with asbestos pulp or old asbestos pipe-covering.

3rd. Build a V-shaped fire-brick shield in front of the pipe or use half-circular fire-bricks.

Either of the latter methods is preferable to the first as they permit easier inspection of the pipe.

Surface Blow-Off In addition to the bottom blow-off pipe every boiler should be provided with a surface blow-off, which will assist materially in preventing the formation of scale. By using the surface blow-off several times a day when the boiler is under pressure, the scum or foreign matter may be removed, which, if allowed to remain, will settle and form scale.

Feed-Water Connections Cold water should never be fed into a boiler, as it is injurious to the plates and may spring the seams and cause them to leak. A good feed-water heater should be used. It will not only save repairs to the boiler but will effect a great saving in fuel.

Where for any reason a feed-water heater is not used, the feed-pipe should be continued inside the boiler in order that the water may be warmed as much as possible before it is discharged into the boiler. In fact, it is best to do this even when a feed-water heater is used. The feed-water should be discharged at a point where it will not chill the shell, and where the scale deposited will work the least possible mischief.

In the case of a horizontal tubular boiler, the feed-pipe should enter through the front head above the top row of tubes and below the water line and at one side between the shell and the outermost tube. Thence the pipe should extend back about two-thirds the length of the boiler, cross over, and discharge through a plain elbow downward and forward between the center rows of tubes. The use of a feed-pipe discharging in this way will prevent a deposit of scale on the side sheets and will also prevent the straining of the sheets by cool water impinging upon them.

The portion of the feed-pipe in the boiler should be suspended by stout wires from the braces and not be allowed to rest upon or across the tubes. Tubes are sometimes cut through by the continual movement of the feed-pipe upon them, due to the pulsations of the feed-pump. The pipe should be put together in sections so that it may be removed and cleaned.

Drip-cocks should be arranged at the lowest point so that the feed-pipe can be thoroughly drained when laying up a plant.

There should be placed in the *feed-pipe* to *each* boiler a *check-valve* and a *stop-valve*, the stop-valve being between the check-valve and the boiler, so that repairs can be made to the latter while the boiler is under pressure. Feed-pipes and check-valves should always be arranged so that the water cannot back out of one boiler into another. The main return-pipe to a heating boiler (gravity return system) should have a check-valve, and between this check-valve and the boiler there should be placed a stop-valve.

A horizontal tubular boiler should never be fed at the front and bottom under the tubes, as the sediment in the feed-water will settle on the plates over the fire, and burning of the metal may result. Moreover, when the boiler is fed at the front, the sediment will settle down so far from the blow-off pipe that blowing-off will not remove it.

A good feed-water regulator will prolong the life of a boiler by averting the stresses set up by the continual variation of the water-level, which almost necessarily occurs in hand-feeding. It will also obviate the dangers of high and low water. Such a device, however, should be frequently inspected, and should never become a substitute for care and watchfulness on the part of the attendant.

It is always safer to have two independent means of feeding a boiler. Then if one means fails, the other is available and may thus prevent disaster.

Use crosses with brass plugs in the blind ends on feed-water piping instead of elbows, to permit of cleaning with a wire in both directions. Cleaning should be done frequently, particularly with scale-forming waters. Also examine the check-valve every time the boiler is cleaned.

Water-Column Connections Pipes connecting the water-column with the boiler should never be less than one and a quarter (1¼) inches in diameter, and should be of brass, to resist corrosion. In general practice one and one-half (1½) inch pipe is better. The connections should be as short and as direct as possible. When shut-off valves are placed between the water-column and the boiler they should be locked or sealed OPEN and so placed that no water can be pocketed.

Every water-column should be equipped with a blow-off pipe or drain three-quarters (¾) of an inch or one (1) inch in diameter. For convenience this should be piped to discharge into the ash-pit. This blow-off may be provided with any good valve or cock, but if the latter is used, a closed-end wrench should be provided, as an adjustable wrench is too apt to be misplaced, and the blowing-out in consequence neglected.

No connections except for damper-regulator, drains, or steam-gauges, should be placed on the water-column or the pipes connecting it, and it is best to connect the damper-regulator elsewhere.

Flange-joints or unions with rubber packings should be avoided. Serious accidents have occurred after renewing a gasket due to putting in a blind one through an oversight.

Crosses with brass plugs in the blind ends should be used instead of elbows in water-column connections, to permit of cleaning in both directions when the boiler is shut down for cleaning purposes.

Gauge-Glasses and Gauge-Cocks The height of the gauge-glass should be such that when the water appears in the glass there will be a safe depth of water (3 inches to 5 inches) over the tubes.

In the latest and best practice, gauge-cocks are placed directly on the boiler as well as on the water-column.

The gauge-glasses must *not* be relied upon, but must be checked by the gauge-cocks frequently. It is advantageous in some situations to use in place of the ordinary gauge-cocks, ⅜-inch to ½-inch angle-valves, with nipples screwed into the angle-valves and inclined to one side and opening freely into the air, so that the fireman may know whether steam or water is vented when a valve is opened. It is not advisable to provide a waste-pipe to receive the ends of the nipples.

The bursting of gauge-glasses when it occurs frequently is usually due to:

1. Defects in the glass.
2. Improper packing, the glands not being in line.

Only the best Scotch glasses should be used, as these are most likely to be free of defects, and the glasses should be carefully packed.

The danger to the attendants from the bursting of gauge-glasses naturally suggests the use of a safety device in the form of a guard. But the use of a guard makes it less easy to keep track of the water-level, and the danger of low water through wrong readings is thus encountered.

Where the conditions will permit the use of a guard, either of the following arrangements will prevent the glass from flying and will deflect the steam and water to some extent, thereby enabling a safer approach for closing the valves:

1. Place a V-shaped or semi-circular shield of Mississippi wire-glass in front of the gauge-glass.
2. Enclose the glass in a metal shield which is slotted to permit observation of the water-level.

The use of pendant chains from lever-operated valves will also be of assistance in closing after breakage.

In case of breakage, close the water-valve first. When a new glass has been inserted, step out of range and open the water-valve first.

Incrustation or Scale Scale is the most frequent cause of the minor boiler accidents. This seems not to be generally known to boiler owners, for inspectors find a great deal of scale in boilers, and boiler owners exhibit but little interest when scale is reported to them. Just so certain as scale is allowed to accumulate to any considerable extent in a boiler, just so certain will a bag or rupture of the boiler occur, unless perchance the scale happens to be of a spongy formation, which however is not often the case. By the overheating of the plates due to scale, oxidation or "burning" of the metal will occur, reducing its strength and often causing cracks. Overheating will also cause the seams to leak and will loosen the tubes in the heads. The damage done to boilers by unsuitable waters, i.e., by those having a large scale-making content, is enormous.

Scale endangers the safety of boilers in other ways. It clogs the feed-pipes and prevents the feed-water from entering the boiler freely. It clogs the connections to the steam-gauge and causes the gauge to read incorrectly. It clogs the connection to the water-gauge and causes it to indicate ample water when there is none at all in the boiler. It clogs the blow-off pipes. Pieces of it get under valves and prevent their closure. A blow-off valve, for instance, screwed down hard and thought to be shut, may allow all the water to leak out of a boiler and cause it to be damaged irreparably.

The presence of scale on the heating surfaces lessens the efficiency of a boiler very considerably, though it is difficult to say just how much. The extent of the loss depends upon the thickness of the scale and also upon its physical and chemical character. The relative effect of oil is far greater.

No one process and no one antidote will suffice to prevent all kinds of incrustation. Scale is usually due to one or more of the following causes:

1. Deposition of suspended matter.
2. Deposition of alkali salts by concentration.
3. Deposition of carbonates of lime and magnesia by boiling off carbonic acid, which holds them in solution.
4. Deposition of sulphate of lime, which is more soluble in cold water than in hot.
5. Deposition of other magnesia compounds due to their decomposition in the boiler.
6. Deposition of lime-soap, iron-soap, etc., formed by saponifications of grease.

The principal impurities in the water used for land boilers are commonly carbonate of lime and sulphate of lime, more or less organic matter, and occasionally sand or clay in suspension.

Scale may be prevented or lessened by:

1. Filtration of water before feeding to the boiler, or use of large settling tanks.
2. Chemical treatment of water outside of boiler.
3. Heating feed-water and collecting scale in a heater or purifier.
4. Blowing off the boiler at regular intervals.
5. Use of internal collecting-apparatus in the boiler.
6. Chemical treatment or other treatment of water in the boiler.

When a water is bad it is best to reject it altogether if possible and secure a good water. Where this is not possible, the removal of the solids from the water and the neutralization of the acids outside the boiler is by far the best course to pursue. Filtration or settling in tanks will remove most of the matter held in suspension, but will of course have no effect on the matter in solution. The use of heaters or purifiers, or chemical or other treatment, will be required in the case of the dissolved matter.

In the chemical treatment of the water, the various preventives and solvents may be added to the water previous to pumping it into the boiler, and the precipitates thrown down removed by filtration or settling, or the preventives and solvents may be introduced directly into the boiler.

Trouble due to the carbonates of lime and magnesia is best remedied by the addition of soda ash or tannate of soda to the water. The magnesia compounds form deposits which are mostly light and porous, so that in general there is but little to fear from them. Carbonate of lime seldom forms a stony scale. It may collect in large masses and do serious injury to the boiler, but the deposits it forms are generally lighter and more porous than those formed by sulphate of lime.

The sulphate-of-lime scale is more troublesome and is much more likely to produce injury to a boiler than a carbonate-of-lime scale of the same thickness. The scale formed by sulphate of lime is hard and adherent, and closely resembles stone. Soda ash and tannate of soda are both of great value in preventing the formation of this dangerous sulphate scale.

The scale preventive that should be used in a boiler should receive the most careful attention and should be selected with especial reference to the conditions. A boiler is one of the worst possible places in which to carry on chemical reactions; the reactions are liable to cause corrosion of the metal. Soda ash, a crude carbonate of soda, is probably the most effective scale preventive and solvent. Being alkaline, it neutralizes any acids that are present. It reacts with sulphate of lime to form carbonate of lime and sulphate of soda.. The carbonate of lime, even when it forms scale, is less dangerous, as has been noted, than sulphate of lime, and much of it can be gotten out of the boiler by the use of the blow-off pipe. The sulphate of soda is soluble and will pass out through the blow-off. Carbonate of lime forms a less troublesome scale when soda ash is present than when it is absent, even though no chemical action takes place. The addition of a little caustic soda to the soda ash is often very helpful.

Inasmuch as the scale-forming matter is distributed uniformly throughout the feed-water, it is essential for the best results that the preventive or solvent used be introduced in small quantities continuously rather than at intervals in large quantities. It is the practice in some plants to introduce the soda ash or other substance only upon starting up after the boiler has been shut down for cleaning, a large amount of the preventive being put in at this time with the idea that it will suffice until the next periodical cleaning is due. This idea is a fallacy and such use of the preventive is very wasteful and inefficient, for the original charge will have been entirely blown out of the boiler long before the time for introducing the next charge comes. It is a good plan, however, when filling a boiler with fresh water after cleaning it out, to introduce a *few* pounds of the soda ash or other preventive at the start. Thereafter, for continuous feeding when soda ash (sodium carbonate, Na_2CO_3) is used, from two to five pounds per week should in general be sufficient, though the quantity that gives the best results will have to be determined by experiment. The soda ash should be dissolved in water and passed into the boiler by means of a pump or an injector, an attachment to the suction-pipe being provided for the purpose.

Where the quantity of dissolved salts in the water is large, scale preventives are not of much use. In such cases the use of the water must be abandoned, or the water freed of the scale-forming matter before it is allowed to enter the boilers.

The use of tannic or other acids, or of crude petroleum, is inadvisable. Tannic, acetic, and other acids, attack iron. The so-called "crude oil," in addition to forming a sludge on the heating surfaces, often gives rise to another difficulty, as it often consists either wholly or in part of oil that has been partially distilled, and in such cases the sulphuric acid that is used in the treatment is not always neutralized and may corrode the boiler.

Refined kerosene oil continuously fed in small quantities is beneficial in some instances. The kerosene forms a thin skin of oil on each particle of solid matter and thus prevents the particles adhering closely and forming a solid mass. An automatic sight-feed may be used for introducing the kerosene into the boiler. *Vegetable oil and greases are exceedingly injurious.*

If an open feed-water heater, that is, a heater in which the exhaust steam and the feed-water come into direct contact and mix, is used, the introduction of the soda into the heater will often precipitate a large amount of scale-forming matter there, thus preventing it from getting into the boiler at all. In such cases the heater should be well flushed every few hours by the blow-off pipe, and a settling chamber utilized to remove the matter held in suspension in the water.

When soda ash or other solvent is introduced into a boiler in which scale may have formed, the boiler should be opened shortly afterwards and whatever scale has accumulated on the sheets removed. Otherwise serious trouble is likely to be caused through the overheating of the metal. The surface and bottom blow-off pipes should also be opened at frequent intervals to prevent the density of the solution from becoming too great, as otherwise priming is liable to ensue. The surface blow-off may be made in the form of a flat cone fixed at the water-level inside the boiler and half submerged in the water. This blow-off may also be used in removing any organic matter that may collect on the surface of the water.

The use of a "scale pan" has proved useful in many instances in preventing the deposition of scale on the plates. This is a shallow pan about four to six feet long and as wide as can be passed through the man-hole. It is supported by light legs about three (3) inches long and is placed on the fire-sheet directly over the grates. As the scale falls it is caught by this pan and thus kept off the sheet and prevented from causing the bagging of the sheet. Where such a pan is used, however, it should not be depended upon in the least to the extent of lessening the frequency of internal cleanings and inspections.

To rid a boiler of accumulated scale and oil, first empty the boiler (after the steam pressure has died down), and take out as much of the scale as can be easily removed by mechanical means. Then fill the boiler with water to within a few inches of the top and put in about forty (40) pounds of caustic soda (sodium hydroxide, NaOH) per 100 H. P., i. e., per about 20,000 pounds (320 cubic feet or 2,400 gallons) of water, and let it simmer for forty-eight hours (or longer if possible) at little or no pressure over a *very gentle* fire. Allow the boiler to cool and blow down thoroughly, then enter the boiler and scrape off whatever scale has remained stuck fast. This process should make the scale very soft, but it may harden again on exposure to the air and for this reason the boiler must be cleaned quickly after the water is let out. It may be necessary to repeat this operation several times before the boiler is perfectly clean.

Great care should be exercised in handling the caustic soda. It should not be gotten on the hands and especially should it not be gotten into the eyes. It should not be handled with the bare hands. If it is used, a bottle of dry bicarbonate of soda should be kept in the boiler-room to serve in case of emergencies. Then if by any mischance, some of the caustic soda gets into anyone's eyes, a handful of the bicarbonate of soda should be put into a wash-basin of cold water and stirred up, when the face should at once be thrust into the solution and the eyes opened if possible. The bicarbonate of soda converts caustic alkaline substances into carbonates and has itself no injurious effect on the eyes.

The absolute necessity for the periodical use of the blow-off pipe should not be overlooked. After the scale-forming matter has been precipitated by heat or by chemical action, it remains in suspension for some time, and if the circulation in the boiler is interrupted for some time, as for instance, when shut down at night or when the fires are banked at the noon-hour, the matter will collect mainly where the circulation is least active, namely, at the rear end of the boiler, and may be blown out. The best time to blow out is in the morning before starting up and at the end of the noon-hour.

The feed-pipes, water-column connections, and blow-off pipes of boilers, should be watched carefully and kept clear of scale. If not properly attended to, they will choke up with scale. The same degree of careful attention is necessary also in the case of coil-heaters, water-grates, and water-tube boilers. The most troublesome form of scale is that deposited in pipes exposed to the fire; here it "bakes on" hard and is very difficult to remove.

Boiler Compounds The promiscuous use of boiler compounds, fluids, powders, or like substances is inadvisable. Unless their composition and how they will affect the impurities in the boiler water and the boiler itself is positively known, they had best not be used at all.

In the treatment of boiler waters it is always best to start with a careful analysis of the water and then have the compound to be used made up accordingly.

A manufacturer of a reputable compound will willingly name the elements of his mixtures and also the kinds of water for which it is best adapted.

Feed-Water Heaters Provided the exhaust steam is at or about atmospheric pressure (which will always be the case with engines run non-condensing) and provided the supply of steam is sufficient, an open feed-water heater will throw down such scale-forming matter in solution as is precipitated at a temperature of 210° Fahr. or under.

Water containing carbonates of lime and magnesia, mud, or other substance held in suspension, may be most easily purified perhaps by using the open type of feed-water heater. The main objection to this, however, is the fact that the usual open heater does not remove all the oil from the steam but allows some to reach the boiler. The oil chamber in this design of heater should be large and the makers should guarantee entire removal of oil. A large settling chamber or hot well should also be provided in which may be placed, if desired, a filtering bed of suitable material to remove from the water all the impurities held in suspension. A blow-off of large diameter should be placed at the lowest point in the heater and used every few hours to flush out the heater.

The closed feed-water heater has an advantage over the open heater in that the oil in the exhaust steam cannot mix with the feed-water owing to their entire separation. To offset this advantage, however, the surface of the tubes on the steam side may become coated with a film of oil and on the water side with scale, so that the efficiency of heat transmission is decreased. The further fact that there is no means of readily removing the scale from the inside of the closed heater is an obstacle to its use with many waters.

A "live-steam" purifier* may be used to remove the sulphates, as well as the carbonates, by heating the feed-water by live steam to a temperature due to the boiler pressure. Sulphate of lime is thrown down at 280° Fahr., corresponding to a gauge pressure of 35 pounds. Such purifiers must, of course, be strongly built. In these purifiers, the internal arrangement is such that the water drips or trickles over successive pans placed vertically over one another. The scale-forming matter is deposited in these pans and the entire nest of pans may be removed for cleaning. It is well to supply the feed-pump with steam from the purifier, so that the carbonic-acid gas, the air, and the other gases given off by the water may be removed. The purifier is placed above the boiler at a sufficient height to permit the water to drop down to the boiler by gravity.

The open feed-water heater and the "live-steam purifier" working in conjunction will give the boiler practically pure water, which in turn adds much to the safety of operation.

All open feed-water heaters should be provided with an automatic overflow-valve or other arrangement to care for the heater in case the regulating valve for the supply fails to work. Where no such provision is made and the water-level in the heater should rise above the exhaust opening, there would be nothing to prevent the flooding of the engine and a probable serious breakdown. Some heater manufacturers recommend that an ordinary low-pressure trap be connected to the heater, and say that this is as necessary to the heater as a safety-valve is to a boiler.

---

* Patented.

Power Cleaners These should be kept in motion during their use so that they will not strike an undue number of blows on any one part of the tube. The pressure used should not exceed twenty to thirty pounds per square inch. Compressed air should be used to operate tube cleaners unless the motive power is external to the tube. In case steam exhausts into the tube it should not be permitted to blow through the tubes of a cold boiler long enough to heat them to any extent. Finally, the boiler tubes and headers should be carefully watched during and after the operation, which should only be done by a skilled attendant.

Corrosion Corrosion is frequently caused by the use of feed-water containing free sulphuric acid or acid salts, such as are often found in streams or ponds in the vicinity of coal mines, or in streams polluted by the discharge into them of refuse from dye-works, chemical factories, etc. The use of such water should be avoided, but if no other supply is available the water should be neutralized with an alkali, such as soda ash, preferably before it enters the boiler. When the neutral point is reached, the water will cease to turn blue litmus paper pink. The proper amount of alkali to add may be approximately judged in this way. Care must be taken not to use too much alkali, as it may cause the boiler to foam and prime.

Lubricating or heavy oil in boilers is a prolific source of burned plates, bags, and blisters. Every effort should be made therefore to keep such oil out of the feed-water. When the feed-water is heated by direct contact with exhaust steam it should be examined carefully from time to time, as oil is very apt to be present in a more or less dangerous amount.

Ashes often attach themselves to the shell, especially in internally-fired boilers, and as they absorb moisture, external corrosion is soon a result. As a cautionary measure, never cool any ashes with water while they are under the boiler grates.

When leakage occurs in a joint which is hidden by the brickwork, the plates may be corroded very seriously without the fact being discovered. External corrosion should be prevented by keeping the boiler shell free from moisture, and by repairing all leaks as soon as they appear.

It is particularly important that lard tanks, rendering tanks, dryers, and tanks and other vessels used for like purposes, in fertilizer factories, packing houses, soap works, etc., should be watched carefully for local and general corrosion. The acids in the fats quickly destroy the metal. Frequent inspections, both internal and external, are therefore indispensable.

Oil Removal Wherever the exhaust steam comes into contact with the feed-water, or oily drips are returned to the boiler, an efficient oil separator or filter should be installed. Every separator should be provided with a gauge-glass and be drained at frequent intervals. But it is far better to throw oily drips away.

Probably the most effective filtering medium is linen terry, which is used in some of the filters now on the market. This strains the water as it passes from the feed-pump to the boiler. The terry may be removed, boiled in water and soda, and used again. Hay, straw, charcoal, and coke, are also used. If used too long, they will become clogged, and should therefore be renewed frequently.

Laying Up a Boiler If it is intended not to use a boiler for some time, it should be emptied of its water and thoroughly dried out. If the air is so moist that the inside of the boiler is not dried by the air circulation, a pan of charcoal may be lighted and set inside the shell for a few minutes. When this is removed, it is well as an extra precaution to place a box or pan of quicklime inside the boiler before closing it up. If this is done, however, the box should be so constructed that the lime cannot come into contact with any of the metal parts, or corrosion may result. After making sure that the inside of the boiler is dry and will remain so, the boiler should be closed up and the exterior given a good coat of linseed oil. These precautions will prevent largely the oxidation of the metal. All fittings should be well painted.

If for any reason the foregoing plan of laying up the boiler is impracticable, the boiler should be filled quite full of water. To this should be added soda ash or common soda in the proportion of fifty (50) pounds to one hundred (100) cubic feet of water. The air should then be boiled off and the boiler closed up tight. Whether the method of laying up set forth in this paragraph or the preceding paragraph is adopted, the boiler should be thoroughly cleaned before starting it up again.

In laying up, the furnace, combustion chamber, tube ends, etc., should be thoroughly cleaned of soot, to prevent corrosion.

Boilers that are used only part of the time, should, after being cleaned, be filled full of water.

A boiler out of use, if not properly cared for, will deteriorate much faster than a boiler in use.

Precautions in Entering a Boiler

Never get into a boiler without mentioning the fact to other persons about the power plant. Be sure the blow-off cock is closed, to avoid sewer gas, or scalding water from another boiler. It is an excellent plan to lock shut the valves on the boiler steam, feed, and blow-off pipes during cleaning and inspection, to prevent accidental opening of them while someone is inside the boiler.

It is dangerous to take off the man-hole cover before all the pressure has had time to die down. Pressure gauges often show zero pressure when there is still some two or three pounds pressure in the boiler. A pressure of only two pounds on every square inch of a man-hole cover is quite sufficient to blow it off with violence and severely injure those in the act of taking off the cover. Many serious accidents have occurred in this way. To avoid such accidents and to make sure there is no steam pressure left in the boiler after the water has been blown out, it is a wise precaution before taking off any covers to lift the safety-valve or open the water-column connections.

After opening the man-holes and the hand-holes, close all doors and open the damper. This will produce a current of air through the boiler and up the chimney. It is particularly important to do this on opening up a boiler in which kerosene has been used, or to which other oil, or sewer gas, may have gained admission. Be careful also not to have any lights in or near the boiler until it has been thoroughly aired out. If any inflammable vapor is present, it may ignite and cause serious personal injuries.

Never enter a boiler with a naked light, such as a candle, lamp, lighted match, etc., without first holding the light down in the boiler at arm's length, or preferably suspended on a stick. If the boiler contains an inflammable mixture, due to oil or sewer gas, the explosion will then take place before the man enters. Many serious, and several fatal, explosions have occurred from neglect of this simple precaution. It is well to use a portable electric hand-lamp (see pages 95 and 96 of this pamphlet where two safe types of lamp for this purpose are shown. Serious, and occasionally fatal, shocks have been suffered through the use of faultily constructed electric hand-lamps in boilers).

Before entering the combustion chamber, the ashes should be hoed out of it. Some attendants, instead of taking them out, make a practice of wetting them down with a hose. This not only damages the setting walls, but also leaves the combustion chamber in a dangerous condition to be entered. Many a serious burn has been received by crawling into a combustion chamber which has been treated in this way, and sinking through a cold crust of six or more inches into red-hot ashes. Heat may be retained beneath ashes in this manner for several days.

Internal Inspections Each time the boiler is put out of service a thorough internal inspection should be made. This is the only certain method of knowing the condition of the boiler and is the best safeguard against accident.

Examine all stays and see that they are taut and in good order. Look for pitting around any drum connections and for grooving in the side seams. Examine carefully all outlets and pipe connections, as they are specially liable to corrosion. Clean and wash pipe connections to water-column every time the boiler is cleaned. Careful attention should also be given to the seams to make sure that no cracks have developed. If the existence of a hidden crack is suspected, and hidden cracks, as has been already noted, are particularly liable to develop in the longitudinal seams, the rivets should be cut out and the plates separated for examination.

Mud-drums should be given careful attention and cleaned and inspected regularly just the same as the boiler. Blow-off valves and piping, especially nipples to the mud-drums of water-tube boilers, should be sounded with a hammer at each cleaning.

In locomotive and vertical boilers, clean and wash out the water-legs frequently.

Just as soon as the man-hole cover has been fastened in its place, turn on the feed until "two gauges" of water are gotten. Fires have been built under empty boilers due to forgetting to turn on the feed, and costly repairs thereby made necessary.

Boiler-Room Rules The following rules should be framed and posted in a conspicuous position in the boiler-room for the guidance of the men in charge. Copies of these rules, suitable for framing, may be had from the Company on request.

BOILER-ROOM RULES

Persons having the care of boilers should remember that explosions or other accidents are often due to *lack of care on the part of attendants.* The careful observance of the following rules will go far to prolong the life of boilers and to prevent casualties.

1st. On entering the boiler-room, ascertain if the valves between the boiler and water-column are open. Then blow down water-column, noting the return of the water in the glass, and test the gauge-cocks, until absolutely sure of the water-level. This should be done at the beginning and end of each watch.

2nd. Open each door to boiler at least once a day and look carefully for leaks at every possible point, noting tube ends, seams, and blow-off pipe in furnace. Examine carefully the fire-sheets for bulges, bags, or blisters.

3rd. Have all defects and leaks repaired without delay.

4th. Safety-valves are liable to stick on their seats; they should therefore be raised carefully at frequent intervals. Attach a small wire cable to safety-valve lever, pass it over a pulley, and bring the end down to a convenient place for ready service in lifting the valve. See that the outlet to each and every safety-valve is full size of valve opening. When washing out boiler, oil safety-valve with cylinder oil.

5th. When steam-gauge indicates maximum load on safety-valve approved in last inspection report of The Fidelity and Casualty Company, the safety-valve should be blowing off freely. If it does not, ascertain at once why not.

6th. Keep gauge-cocks in good order and *use* them, as water-glasses are very unreliable. Place tees or crosses at the bend of both pipes from boiler to water-column; remove the plugs and clean these pipes when washing out boiler.

7th. In case of foaming, close the throttle long enough to show the true water-level in boiler. If the level is sufficiently high, feeding and blowing down will usually correct the evil. If foaming becomes violent, check the draft and use surface blow-off freely. Ascertain the cause of the foaming, and take the necessary steps to prevent the evil.

8th. In case of low water, cover the fire with wet ashes, or with green fuel if wet ashes are not available, and close the fire and ash-pit doors. *Don't touch the safety-valve. Don't turn on the feed-water under any circumstances.* Let the steam outlets remain as they are until the boiler has been cooled off and examined to determine what damage has been done.

9th. When connecting boilers, exercise great care. See that the pressures on the steam-gauges agree before attempting to open the steam-valves. Open the valves very slowly, and, if provided with small by-pass valves, use these before opening the large valves. Never connect boilers unless the steam pressures agree. Many explosions have been caused by neglect of these precautions.

10th. Do not close the damper entirely when there is fire on the grates, as gas may collect and result in an explosion as destructive of property as a boiler explosion.

11th. Provide a V-shaped brick pier or asbestos cover to protect the blow-off pipe from direct flame in furnace. Have this pipe extra heavy with malleable elbow. Once or twice a day blow down about two inches of water. The best times to use the blow-off are the first thing in the morning and directly after the noon-hour, on each occasion before starting up; the circulation has then been retarded for some time and the scale-forming matter has had opportunity to settle near the blow-off. Open and close blow-off cock slowly to avoid water-hammer.

12th. Keep the boiler dry on the outside, as moisture will cause external corrosion.

13th. Keep the brickwork tight so that cold air does not enter, as it will cause fuel losses. Fire lightly and frequently and endeavor by all means to save fuel for your employer. Endeavor to carry a uniform water-level when boiler is in service. Keep the feed-pumps, injectors, and all other appliances, in good working order and as neat as possible.

14th. Wash out the boiler at least once every month and more often if the feed-water is bad. Do not allow mud or scale to accumulate in the boiler and do not allow oil or grease to enter the boiler; these foreign substances may cause overheating and burning of the plates and result in a bag, rupture, or violent explosion. A solution of soda ash or a small quantity of kerosene fed continuously into the boiler is often beneficial in preventing or softening scale; when these substances are used open blow-off cock once or twice a day as in rule 11th. If kerosene is used, great care must be exercised to see that it is entirely gotten rid of by allowing a draft to blow through the boiler before bringing a naked light to the boiler or allowing anyone to enter the boiler, as an explosion may ensue or the fumes may overcome the person entering.

15th. When a boiler is to be cleaned, allow the fire to die out, and leave the dampers open with fire-doors closed for at least twelve hours, when the steam-gauge should indicate no pressure. Then admit air on top, open blow-off cock, and allow the water to run out. Remove the upper man-hole plate, and use vigorously a large hose with ample water pressure to dislodge loose scale, and wash out the boiler thoroughly. Now remove the lower man-hole plate and all the hand-hole plates, and entering the boiler, remove the lodged scale at the turn of the flanges and below and between the tubes. See that all parts of the boiler are entirely free of scale and clean internally and externally from head to head, and see that the furnace is cleaned out from end to end. Examine carefully all parts of the boiler for defects, particularly the parts that are subjected to the direct heat of the furnace. See that any leakage at tube ends, or elsewhere, is stopped immediately, and that any tubes found bagged, or any any other defects, are repaired at once.

16th. Have all steam-gauges tested by the inspector. The gauges should be placed on siphons and attached so that they may be readily taken down for test.

17th. The inspection of a steam boiler is a matter of vital importance. When notified to prepare a boiler for internal inspection, proceed to cool down and clean the boiler as per instructions given in rule 15th. Remove all scale, clean out the ashes and soot on the grates and in the combustion chambers, and sweep off the plates, heads, and tubes, so that every part of the boiler may be examined and its exact condition determined. Have the boiler cold for the inspector when he arrives. Have the steam-gauge ready for testing, water-column connections open for inspection, and everything in readiness to facilitate a thoroughgoing inspection of the boiler and its connections. Careful compliance with this rule will protect your employer's interests and your own also.

The Inspectors of the Fidelity and Casualty Company will give Special Instructions in matters not covered by these rules.

Additional Boiler-Room Rules

Never attempt to calk a leaky seam in a boiler under steam pressure. The jar caused by the hammer-blows may cause a rupture of the seam. This caution applies also to steam-pipes and valve-casings. A round-nosed tool should be used in calking boilers.

Before breaking any steam-pipe joints to make repairs, or to renew gaskets, etc., the dead section should be well drained. Workmen have been scalded when breaking joints due to some pressure still remaining in the line after the main valves were closed.

In case the feed-pipe of a boiler gives out, or water cannot be supplied to a boiler for any reason, the boiler should be shut down at once and the fires drawn.

Watch safety-valves carefully to be sure that they do not corrode fast to their seats.

The pipe connecting the steam-gauge should be cleaned out at least once a month by blowing steam through it. When the gauge is off, the hole in the nipple should be perfectly clear.

When observing the glass water-gauge while the boiler is working, note particularly whether the water in the glass is stationary or not. If the water-level does not fluctuate, it is an infallible sign that the gauge is out of order. Test the gauge and water-column immediately, and if draining them fails to clear, the boiler should be shut down until the apparatus for indicating the water-level has been repaired.

When there are two or more boilers on one line, those not in operation should be shut off from the header.

A small leak in a boiler may be detected by a white wedge-shaped mark on rivets or plate. In calking, chalk or otherwise mark all the leaks first, as the hammer-blows may destroy the faint indications due to the leak.

Never lose an opportunity to compare the steam-gauge with the safety-valve when the latter blows off. If they do not agree, ascertain which is incorrect.

Always bear in mind to clean out a boiler thoroughly after doing any hammering on it, as scale may have been dislodged and have dropped down on the fire-sheet. Bags and serious ruptures have resulted from neglect of this precaution.

In winter, if the boiler is exposed to cold, close the valves between the boiler and the water gauge-glass when the boiler is shut down for the night, and let the water run out of the glass. Also leave all drain-cocks on pipes, etc., open.

Blowing Down Boilers A boiler should be blown down through the bottom blow-off pipe several inches at least once a day, and two or three times if possible. It is best to have a regular time for doing this, as, for instance, in the morning just before starting up and at the end of the noon-hour. These times are named because the scale-forming matter will have settled at the bottom of the boiler then, and may readily be blown out before it hardens on the sheets.

Never open or close the blow-off cock suddenly, as water-hammer is caused thereby. The resulting shock may burst the pipe with serious, if not fatal, results to the attendant. Under no circumstances remove the cap of the blow-off cock while the boiler is under pressure.

If possible have a second man watch the water-gauge when the boilers are blown down, so that the water-level may not be lowered below a safe point. It is well, before starting to blow down the boiler, to test the gauge-glass by opening the drain-cock under the glass, and draining the glass to make certain that it does not indicate a false level.

Close the blow-off cock before leaving the boiler, if suddenly called away while blowing off.

If the blow-off pipe is equipped with both a valve and a plug-cock, the valve should be closed first when the boiler is blown down under pressure, for the reason that as the disk of the valve nears its seat, water rushes through the space at high velocity and clears the passage of any pieces of scale that might otherwise find lodgment.

When a boiler is shut down preparatory to cleaning, it should not be blown out under pressure and cooled off quickly. Instead, the boiler and its brickwork should be allowed to cool before the boiler is emptied (see Boiler-Room rule No. 15, page 49). The removal of scale is made much easier when a boiler is permitted to cool down before blowing off. If blown out while hot, the heat of the boiler and of the brickwork will bake the mud and scale on the shell and tubes, and the baked-on matter will be extremely difficult to remove. The sudden cooling of a boiler creates stresses that are likely to make the tubes leak and do other damage. The practice of blowing out a boiler and filling it at once with cold water to crack and loosen the scale is destructive and dangerous in the extreme.

When time cannot be allowed for the boiler to cool down in the manner above suggested before emptying, the best plan is to blow off the steam first and then allow cold water to flow into the boiler as the hot water flows out. The level of the water in the boiler should be maintained until the water is cooled down sufficiently, when the cooling water may be shut off and the boiler emptied.

When surface blow-cocks are used, they should be opened frequently for a few moments at a time.

Forced Firing It is bad practice to force a boiler to furnish steam in excess of the quantity it was designed to furnish. In the first place, it is uneconomical, the amount of fuel required to produce a given amount of steam being largely increased. This results from the diminished efficiency of the heating surfaces, caused by the increased velocity of the gaseous products of combustion over them, for the quantity of heat absorbed by a boiler depends in part upon the length of time the heated gases remain in contact with its surfaces. And in the second place, forced firing causes rapid deterioration of the boiler, the unequal expansion and contraction of the several parts of the boiler induced by the intense heat and the exposure of plates, seams, and rivets to the fierce flame having a disastrous effect on the metal. Ample boiler capacity with moderate firing, keeping always well within the capacity of the boilers, conduces to fuel economy and long boiler life.

Guarding of Stokers and Fans, Platforms, Etc. Exposed gears, sprockets, and chains, on the stoker-operating mechanism are often a hazard to the fireman, and should be guarded wherever possible. Guards made of sheet-metal bent to conform to the exposed parts will usually afford ample protection.

If the intake of an exhaust-fan or blower is within reach of a person standing on the floor, or adjacent to a platform, it should be enclosed by a screen of not greater than one-half inch mesh to prevent accidental contact with the revolving parts.

Many accidents are due to the want of proper fencing along the edges of boiler-flues, economizers, coalbunkers, etc., and to the use of temporary ladders, and gangways of planks, in places where permanent and properly railed and fixed ladders and gangways should be installed. Owing to bad light, the risk is often increased.

Patches If for any reason it becomes necessary to put a patch on a boiler, the patch should be put on the *inside*, not on the outside. By putting it on the inside, a pocket in which scale or grease may accumulate is avoided. The patch may be gotten inside the boiler ordinarily if made of an oblong shape, its short width being less than the long diameter of the man-hole.

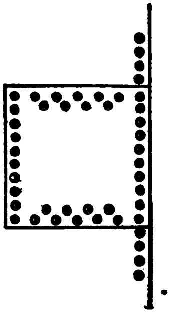


FIG. 4. SQUARE PATCH

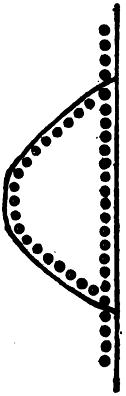


FIG. 5. DIAGONAL PATCH

In putting on patches, it should be borne in mind that in cylindrical shells, the longitudinal stress per unit of section is only half as great as the peripheral stress per unit of section (see page 17, paragraph on "Strength of Boilers"), and the patch should be designed accordingly. Thus a patch with longitudinal edges having an average inclination of 45 degrees to the circular seams, even though single-riveted, may be equally strong as a patch with its longitudinal edges perpendicular to the circular seams, even though the longitudinal edges are double-riveted. The patch shown in Fig. 5 is equally strong as the patch shown in Fig. 4, provided rivets of the proper diameter, properly spaced, are used.

Incipient cracks may often be checked by drilling a small hole through the sheet at the extremity of the crack. This hole may be filled with a rivet, or tapped and filled with a screw-plug.

Hydrostatic Tests

As a general rule the hammer test, that is, going over a boiler inside and out with a hammer, supplementing the sight by the sound of the metal as it is tapped, is to be preferred to the hydrostatic test. But there are cases where a hydrostatic test is indispensable. This is the case of boilers where certain parts are inaccessible for thorough examination, as for instance, the water-legs of locomotive and vertical tubular boilers, and where a doubt exists of the condition of these parts even after the most careful hammer test. Then a hydrostatic test should be applied. A hydrostatic test is also necessary for new boilers. The boiler undergoing a hydrostatic test should be carefully inspected, and any leaks at riveted joints or tube ends and any considerable change of shape signifying weakness, detected.

In making a hydrostatic test, a pressure not in excess of one-third above the working steam pressure of the boiler should be used. This is sufficient to bring into evidence any weakness. A greater pressure will strain the boiler unnecessarily. But if for any reason it seems wise to apply a heavier hydrostatic pressure than is here recommended, the relation of the pressure, proposed to be applied, to the factor of safety should be borne in mind. If the factor of safety is only 4, it is clear that a hydrostatic pressure of twice the working pressure will stress the metal close to the elastic limit, and will thus injure the boiler.

It must not be assumed that because a boiler sustains a hydrostatic pressure successfully, conclusive evidence has thereby been adduced that it is safe. In any case, the hydrostatic test should be supplemented by the hammer test. Thin spots may occur locally in the shell, a mass of scale may cover up a local weakness, or other conditions may exist, which are not brought out by the hydrostatic test. Moreover, the worst stresses that come upon a boiler are those set up by unequal expansion and contraction, and these are not produced in the hydrostatic test.

If in examining a boiler, an impairment of the quality of the metal is suspected, whether by reason of burning or of crystallization, a chip should be cut off by a chisel. Burned or crystallized metal will break off, unimpaired metal will curl up.

Headers and Long Steam-Pipes It is largely current practice where many boilers are set in a battery, to feed the steam from the boilers into a common header or steam line and take off from this header to the engines. Such a header is always a source of danger. It is difficult to suspend it properly, and to provide for the expansion and contraction due to changing temperatures. The better practice therefore tends to direct connections between the boilers and engines without the intermediate header. But if a header is used, it should in the first place be properly suspended and anchored, and in the second place ample provision should be made for expansion and contraction by the use of slip-joints or expansion-loops, the latter being preferred. The expansion-loops should be provided with proper drains. The connections from header to boilers and from header to engines should be sufficiently flexible to allow for longitudinal movement of the header, due to expansion and contraction.

Bisulphite Digesters in Pulp Mills The utmost care in the operation of bisulphite digesters in pulp mills is necessary to prevent the corrosion of the metal in the shells. In spite of the protection afforded by the brick lining, openings will occur in the lead lining, and the acid thus get through to the shell and quickly corrode the metal. Frequent inspections, never less frequently than once a week, are consequently indispensable. The shell, moreover, should be provided with numerous drilled holes to give early notice of a leak in the lining.

The digester-room should be kept warm in winter to prevent excessive contraction of the shells when the digesters are blown out, and thus avoid cracking of the metal.

Rotaries, Dryers, Extractors, Etc. In the case of vessels such as rotaries, dryers, extractors, tanks, digesters, etc., which are operated at a lower pressure than the boiler pressure and are consequently not built to sustain the full boiler pressure, the steam-pipe connecting the boiler with the vessel should be equipped with a stop-valve, reducing-valve, and safety-valve, in the order named, beginning at the boiler end. The reducing-valve will be set to reduce the boiler steam pressure to the steam pressure which it is desired to use in the rotary or other vessel, and the safety-valve will be set to blow off at the pressure which the vessel can safely sustain. The safety-valve should be of ample size to protect the rotary in case of failure of the reducing-valve. If the reducing-valve fails, the steam pressure should be at once throttled down by means of the stop-valve, and the "cook" completed.

Where several rotaries or other vessels are operated from one steam line, a separate stop-valve, reducing-valve, and safety-valve should be provided for each.

As heretofore noted, lard tanks, rendering tanks, dryers, and tanks and other vessels used for like purposes, in fertilizer factories, packing houses, soap works, etc., should be watched carefully for local and general corrosion, and be inspected frequently, both internally and externally.

Omissions The subject of the safe and proper design, construction, and operation of steam boilers and similar apparatus is so vast, and its ramifications are so varied, that it is impossible to treat it adequately within the limits set for this pamphlet. Nothing has been said, for instance, about the size and spacing of stay-bolts for flat and curved plates such as the crown-sheets of locomotive boilers and the water-legs of locomotive and vertical tubular boilers, nor about the design, construction, and spacing of the crown-bars of the crown-sheets of locomotive boilers, nor about the rules for determining the strength of the furnace flues in internally-fired boilers, nor about the setting of boilers. What has been aimed at in this pamphlet is to set forth concisely the more important points regarding safe construction and operation that the average operator needs to know. The points that the average operator needs but rarely, are omitted. When he needs information regarding these, it is best that he consult a capable mechanical engineer, or submit his questions to a boiler insurance company. The Fidelity and Casualty Company will be pleased to answer all such inquiries.

Engines

Guarding of Connecting-Rods, Flywheels, and Belts

The connecting-rod and crank-pin of Corliss engines, except in the case of engines where the design is such as to render guards unnecessary, should be guarded by a double-railed railing, one rail over the other, at least three feet high, placed from twelve to fifteen inches from the nearest moving part. A pipe rail, because more substantial, is preferable to a wooden rail.

The flywheel on an engine of any type, and the main belt running on it, should be guarded by a double-railed railing wherever an attendant may come accidentally into contact with the moving parts. The railing should be placed not closer to the flywheel or belt than twelve or fifteen inches; if placed closer than this, anyone falling on the rail may come into contact with the moving parts. It is not advisable to use a single-railed railing, as a person may fall under the rail, and so on to the wheel or belt. A skirting-board or coaming about six inches high will prevent the projection of feet, and the rolling of articles, into the dangerous area. No clothes should be hung on any guard railings, nor should spanners, oil-cans, waste, etc., be kept inside the railings.

If the railing is placed close to the flywheel, as it is sometimes necessary to do in order to economize space, it should be not less than five feet high, and should be covered with substantial wire netting.

In the case of small high-speed engines where the flywheels are outside of the main bearings and the keys often project from the ends of the crank-shaft, a double-railed railing should be placed sufficiently close, to guard the moving parts effectually.

If possible, wrist-pins should be oiled in some other way than by a lead projecting out from the center of the cross-head. If a projecting oil-lead is necessary, however, the railing around the flywheel should be continued to the front cylinder-head, to guard this projecting part.

Tail-rods should be fenced, or encased in a light metal tube supported from the stuffing-box, when not already guarded by the engine-builder.

Ladders, stairs, and staging, on large vertical engines, should be railed.

Engine-Room Floors Either rubber or burlap matting should be laid down in the most frequented parts of the engine-room, to prevent slipping.

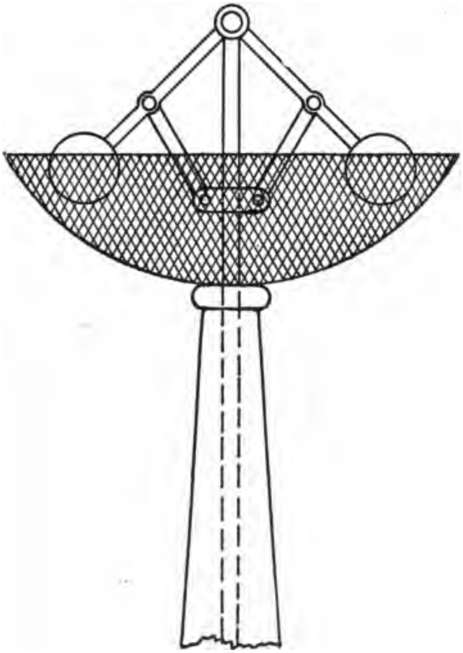


FIG. 6. FLY-BALL GOVERNOR GUARD

Fly-Ball Governor Guard A hemispherical wire-mesh basket placed under the fly-balls, as shown in Fig. 6, is a useful guard, and is absolutely necessary if the governor encroaches at all upon a passageway or a position occupied by an attendant in the performance of his duties.

Air-Pumps The flywheels of an air-pump or an air-compressor should be guarded by a railing placed about six inches from the wheels.

Function of Flywheels The primary function of a flywheel is to moderate fluctuation of speed, although it may unite with this function that of the transmission of power. It may transmit power by belt or rope, or by gear teeth. The impulse from the engine varies, owing to variation of steam pressure on the piston and the angularity of the connecting-rod and crank. There are also periodical variations in the resistance overcome. As a consequence, the flywheel must alternately store up and restore energy, and thus prevent fluctuation of speed through too wide a range. Part of the stresses to which the wheel is subjected arise from this demand, the arms being subjected to bending stresses first one way and then the other. Another part of the stresses come in the form of bending stresses originating in the transmission of power from hub to rim of the wheel. Still another part of the stresses, and a very important part, arises in the centrifugal forces. These are very large when the wheel-rim is moving so fast as a mile a minute, the usual speed. These various stresses make heavy demands upon the strength of the wheel, and as a consequence flywheel disruptions occur frequently. The very best design, material, and construction are required to produce safe flywheels.

Safe Speeds for Flywheels The speed at which a flywheel may be safely run depends upon the material of which it is constructed, upon its design, and upon the conditions under which it is used.

The relative fitness of various materials for flywheel-rims is measured by dividing the tensile strength, T, per unit of area, by the weight, W, per unit of volume. The higher the value of $^{T}/_{W}$, the better is the material fitted for use in a flywheel-rim. The strength of the rim of a flywheel to resist centrifugal force cannot be doubled by doubling the quantity of material in the rim, because the centrifugal force is doubled also when the quantity of material is doubled. It results then that for any given material, the strength to resist centrifugal force does not depend upon the quantity of material in the rim, but only upon the tensile strength of that material, and for any given material in a flywheel-rim there is a definite rim-speed or velocity that cannot be safely exceeded.

The formula for determining the safe rim-speed of flywheels is as follows:

$$V = 97.8\sqrt{\frac{T}{W} \times \frac{E}{F}}$$

in which

V = safe rim-speed in feet per minute.

T = ultimate tensile strength of material in flywheel-rim in pounds per square inch.

W = weight of material in flywheel-rim in pounds per cubic inch.

E = efficiency of joints in flywheel-rim.

F = factor of safety.

In the case of cast-iron, an ultimate tensile strength of 10,000 pounds per square inch is as much, probably, as can be assumed with safety. If then a factor of safety of 10 be taken in a wheel with a solid rim, the formula becomes (E being equal to 1 since there are no joints):

$$V = 97.8\sqrt{\frac{10{,}000}{.26} \times \frac{1}{10}}$$
$$= 6{,}060 \text{ feet per minute.}$$

That is to say, the safe rim-speed for a cast-iron wheel made in one piece does not much exceed a mile a minute. More accurately, a cast-iron wheel, made in one piece and well-proportioned, reaches the limit of safety at a rim-speed of 1.15 of a mile per minute.

But if there are joints in the rim of a flywheel, the factor of safety becomes considerably less than 10. Thus if the efficiency of the joint is only 50 per cent. of the solid metal, the factor of safety in a cast-iron wheel run at a rim-speed of 6,060 feet per minute is only 5, and if the efficiency of the joint is only 25 per cent. of the solid metal, the factor of safety is only 2½.

It is current practice to operate flywheels at a rim-speed of about a mile a minute. The limit of safety, however, varies with the material of which the wheel is built, and in sectional wheels, also with the type of rim-joint employed. Knowing the speed of a wheel, and the efficiency of the joint, the factor of safety may be calculated from the above formula.

The margin of safety on speed may be ascertained by taking the square root of the factor of safety on material. Thus, if the factor of safety on material is 10, the margin of safety on speed is $\sqrt{10} = 3.16$, that is to say, if the wheel reaches a speed of about three times its normal speed it will be disrupted by centrifugal force. If the factor of safety is only 2.5, the margin of safety on speed is only 1.58, or an increase in speed of 60 per cent. will disrupt the wheel. How important it is to keep a wheel from "racing" is thus clear. The stress in the rim due to centrifugal force increases in proportion to the square of the speed.

The following table shows the speeds at which it is safe, in our opinion, to run cast-iron wheels of various types of rim-joints. The efficiencies stated for the joints* comprised in the table are based mainly on experiments made by Professor Charles H. Benjamin, now Dean of Schools of Engineering, Purdue University, Lafayette, Indiana.† In the case of a wheel with no joints, that is, a wheel with a solid rim, the efficiency is of course unity, 1. The usual flanged and bolted joint in belted sectional wheels, with the flanges midway between the arms, has a very low efficiency, only 25 per cent., and very often the efficiency does not run over 20 per cent. This is a very poor design. It may be improved greatly by placing the joints at the ends of the arms, so that the centrifugal force due to the heavy flanges and bolts is sustained directly by the arms, instead of being carried by the rim, and acting on it as a bending force. The efficiency of this type of flanged and bolted joint rises to 50 per cent., and is the same as the efficiency of the pad joint, generally used in wheels made of many sections, illustrated in the table. In heavy, thick-rimmed balance-wheels, where steel links are shrunk on to reinforce the flanged and bolted joint, an efficiency of 60 per cent. may be obtained, but this form of construction cannot be used in belt-wheels having thin rims. A still higher efficiency may be obtained by making the rim of the wheel of I-beam section, placing the joints at the ends of the arms, properly proportioning the joints, and using steel links shrunk in. This is the method followed in the so-called "Haight"[*] type of joint, described in the February 28, April 11, and August 1, 1907, issues of the "American Machinist." It is improbable, however, that any sectional wheel can be made actually as strong as a solid wheel without joints. The subject of rim-joints is worthy of much more study and experiment than has been given to it. It is to be borne in mind that

---

* The efficiencies are spoken of as if they were simply the efficiencies of the joint. This is not strictly accurate. The efficiencies are really the efficiencies of rims with various types of joints as compared with the solid rim, and depend not alone upon the design of the joint, but also upon the design of the rim and upon the bending stresses set up in the rim.

† Transactions of American Society of Mechanical Engineers, vol. xx, page 209, vol. xxiii, page 168, and vol. xxvi, page 232.

$$V = 3.14 \times D \times N$$

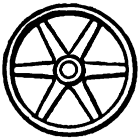
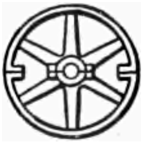
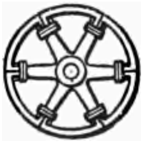
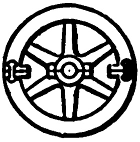
in which

V = rim-speed in feet per minute.
D = diameter of wheel in feet.
N = number of revolutions per minute.

SAFE SPEEDS FOR CAST-IRON FLYWHEELS

Margin of safety on speed, approximately three.[†]

Type of wheels and maximum obtainable efficiency of rim-joint.

	No joint 1.00	Flange joint .25	Pad joint .50	Link joint .60
				
Diameter in feet	R. P. M.	R. P. M.	R. P. M.	R. P. M.
1	1910	955	1350	1480
2	955	478	675	740
3	637	318	450	493
4	478	239	338	370
5	382	191	270	296
6	318	159	225	247
7	273	136	193	212
8	239	119	169	185

---

[*] H. V. Haight, Chief Engineer Canadian Rand Drill Company, Sherbrooke, Quebec.

[†] If the revolutions given in the table be increased 20 per cent., the margin of safety on speed will be reduced to *two and one-half;* if the revolutions be increased 50 per cent., the margin of safety will be reduced to *two.*

SAFE SPEEDS FOR CAST-IRON FLYWHEELS

(Continued from preceding page)

	No joint	Flange joint	Pad joint	Link joint
Diameter in feet	R. P. M.	R. P. M.	R. P. M.	R. P. M.
9	212	106	150	164
10	191	96	135	148
11	174	87	123	135
12	159	80	113	124
13	147	73	104	114
14	136	68	96	106
15	128	64	90	99
16	120	60	84	92
17	112	56	79	87
18	106	53	75	82
19	100	50	71	78
20	95	48	68	74
21	91	46	65	70
22	87	44	62	67
23	84	42	59	64
24	80	40	56	62
25	76	38	54	59
26	74	37	52	57
27	71	35	50	55
28	68	34	48	53
29	66	33	47	51
30	64	32	45	49

NOTE—Margin of safety on speed, approximately *three*. If the revolutions given in the table be increased 20 per cent., the margin of safety on speed will be reduced to *two and one-half;* if the revolutions be increased 50 per cent., the margin of safety will be reduced to *two*.

The stress, due to centrifugal force, in the rim of a flywheel made of any material whatever, and also the bursting speed, may be obtained from the following formulæ:

$$P = \frac{W \times V^2}{2.66} \qquad B = 1.63\sqrt{\frac{T \times E}{W}}$$

in which P is the stress in pounds per square inch when the rim-speed is V feet per second, B the rim-speed in feet per second at which disruption will occur, T the tensile strength of the material in pounds per square inch, W its weight in pounds per cubic inch, and E the efficiency of the rim-joint.

Availability of Various Materials for Flywheel-Rims Wood is a better material for flywheel-rims than cast-iron, and steel is better yet. The best materials of all for this purpose are boiler-plate or steel-wire, and both of these have been used in the construction of special wheels. With wood, boiler-plate, or steel-wire rims, the hub and arms are generally made of cast-iron.

Wooden wheels may be run at a considerably higher speed than cast-iron wheels. For example, a well-constructed maple wheel may be run at a rim-speed of 1.75 miles per minute (approximately 52 per cent. higher speed than a cast-iron wheel with a solid rim), provided the rim is laminated so that 50 per cent. of the material must break to part the rim. It would be unsafe, however, to run some wooden wheels at a speed of a mile a minute, owing to their imperfect construction.

Well-constructed steel wheels may be run with ample margin for safety at a rim-speed of 1.90 miles per minute. The cost of such steel flywheels is so great, however, as to preclude their general adoption.

Design of Flywheels The usual flywheel is made of cast-iron. It is of course the cheapness of the material that recommends it. Provided that the wheel is properly designed, that the best grade of cast-iron is used, that the construction is first-class, that the conditions of service are suited to the limitations of the material, and that the engine on which the wheel is used is equipped with proper safety devices which are kept in working order, cast-iron may be regarded as satisfactory for the purpose.

Small cast-iron wheels are made in one piece. Large wheels are made in halves or sections, to facilitate handling and transportation. It is common practice to make all engine wheels up to 8 feet in diameter in one piece; those between 8 and 16 feet in halves; and those over 16 feet in sections; the number of sections being usually equal to the number of arms in the wheel. Wheels are not often made larger than 30 feet in diameter, although 30 feet is a size frequently encountered.

Wheels smaller than 8 feet are frequently made in halves, either to avoid shrinkage strains or to make it possible to put them on shafts without taking off other wheels. Frequently the hub only is split to obviate shrinkage strains.

Shrinkage strains present a serious problem. They are produced by the unequal rate of cooling of the metal in the arms and rim of the wheel when it is cast. If the mass of metal in the arms, for example, is greater than that in the rim—a frequent case with thin-rimmed pulleys—the rim, because of cooling and shrinking first, is pulled by the more slowly cooling arms, and a bending stress is produced in the rim and a tension stress in the arms. Not only are these shrinkage strains produced by the unequal cooling, but the metal at the juncture of the arms and rim is often left in a dangerously porous or honey-combed condition.

In designing a flywheel, there are four points in particular that should be taken care of in order to produce a safe wheel:

1. *Shrinkage strains.* The mass of metal in the rim should be the same as that in the arms, to avoid undue shrinkage strains.

2. *Position of rim-joints.* It is very bad practice to put the rim-joints midway between the arms. The heavy flanges and bolts make heavy centrifugal force when the wheel is under speed, and this, multiplied by the leverage, brings a heavy stress at the point where the rim joins the adjacent arms. The portion of the rim between the arms is like a beam uniformly loaded, and no one would think of putting a joint in the middle of a beam. It is far and away better to put the joints at the ends of the arms. In wheels made in halves the arms should be split, or better still, double arms should be put along the line of the separation. In multiple-section wheels, pad joints should be used at the ends of the arms. If in any case, it is absolutely necessary to put the flanged rim-joints between the arms, tie-rods should be connected up between the joint and the hub. It has been proved by experiment that such tie-rods actually double the strength of the wheel. Numerous arms in any type of wheel strengthen the wheel greatly by taking up directly the centrifugal forces that would otherwise have to be carried as bending stresses.

3. *Fillets.* Fillets should be generous so as to avoid the shrinkage strains that usually surround sharp corners in castings.

4. *Variations in the load.* In the case of engines in rolling-mills and other works where there are wide variations in the load, the wheel should not be made so light that there will be wide fluctuations in speed, as such fluctuations will put very heavy stresses on the wheel. Where there are wide variations in the load, especial attention should be given to designing the arms of the wheel. On account of the bending stresses, the best form for the arms is the I-beam section. The web of the "I" should of course be parallel to the plane of the wheel, so that the tension and compression stresses due to the bending action will come upon the flanges.

Temptation to Increase Flywheel Speed

Where a flywheel serves also as a belt-wheel and it is desirable to have more power than the belt can transmit at normal speed, there is a great temptation to increase the speed. This is because the power transmitted by a belt is proportional to its width and speed, and any increase in speed, up to the point where the belt begins to slip badly, means that much more power transmitted. The temptation to run flywheels at high speed is therefore very great, so great in fact, that they are often run at a speed dangerously close to the limit of safety. To yield to this temptation is deliberately to invite disaster. The margin of safety on speed, as has been shown above, is narrow, and the speed of a wheel cannot be increased much above the normal without passing the limit of safety.

Causes of Flywheel Accidents

Wheels that serve only as flywheels have narrow, thick rims, often of approximately square cross-section. Those that serve as combined flywheel and belt-wheel have thin rims, wide enough to carry the belt used to transmit the power developed by the engine.

The disruption of flywheels is a more frequent occurrence than is commonly supposed, and many lives are lost and much damage to property is caused thereby. The importance of careful operation of engines cannot be overestimated. The principal causes of flywheel disruptions are overload, overspeed, and defects in the wheel.

Overload may be produced in a number of ways, among which may be enumerated:

(a) Clogging of the machinery in the mill.

(b) An unusual number of machines may be forced at the same time.

(c) Careless or ignorant handling of friction-clutches.

(d) If the engine drives electrical machinery, the overload may be produced by a short circuit.

(e) Sudden stoppage of the engine, as when the piston comes off and blocks the piston-rod.

In many instances the overload is produced suddenly and causes the wheel to fail, either by the torsional stress resulting, or by the crushing stress due to the pressure of the belt acting against the rim.

Overspeed causes the wheels to explode by centrifugal force. By overspeed is not meant especially high normal speed, although many wheels are run normally at dangerous speed. Reference is made particularly to the accidental increase in speed beyond that for which the wheel is designed and the governor of the engine is set, and which is commonly called "racing." "Racing" may be produced by:

(f) Governor being improperly designed.

(g) Slipping or breaking of governor-belt or of governor-pulley.

(h) Derangement of governor by internal or external causes, as when a stem or a rod gets stuck, or a ball is broken off.

(i) Derangement of valve-gear.

(j) Safety-stops improperly set, or governor blocked.

(k) Sudden reduction of load, as when the main driving-belt breaks, or an armature burns out.

Defects in the wheel may consist of:

(l) Defects in the design, or in the material, or in the construction.

In addition to the foregoing causes, the following other causes of flywheel disruptions are important:

(m) Failure of some part of the engine, as when its bed breaks or its shaft fails, and throws the wheel against the side of the wheel-pit.

(n) An idler-pulley or a driving-pulley may break, and derange the governor or valve-gear by hurling fragments into them.

In the case of a condensing engine, "racing" often continues until the wheel is disrupted, even after the engineer has succeeded in shutting off the steam. This is due to the power supplied by the vacuum.

Unfortunately, when an engine starts to "race," the men in charge of the machines in the mill shut them down, and the decrease in load causes a further increase in speed, until the engine, entirely freed of its load, runs away, and disrupts its wheel by centrifugal force.

The most frequent causes of overspeed are (1) a sudden decrease in the load, or (2) the breaking of the governor-belt or of one of the governor-belt pulleys.

The governor of a Corliss engine is usually a heavy piece of apparatus, and any sudden decrease in the engine load produces a stress in the governor-belt that is often too great for it to bear. If the belt lets go and there is no safety device to shut off the steam to the engine when the governor falls, the speed of the engine will rapidly increase until the flywheel is disrupted by centrifugal force.

Engine builders have recognized this danger for some time, and nearly all engines now built are equipped with some sort of device intended to shut off the steam and prevent "racing," should the governor-belt break.

There are, however, many engines in operation that are not supplied with any such device, and these are a menace to life and property.

Some Simple Governor-Stops

Engines not equipped with proper safety-stops by the builder should be supplied with one of the following devices:

Fig. 7 illustrates a very satisfactory device. The end of the governor-rod *a* is formed into a hook *b*, and hinged at the top to permit side motion. If the governor ceases to perform its function because of the breaking of connections between it and the engine, the balls will drop, thus causing the governor-rod to strike the pin *c* below it as shown in the cut, and to throw it out

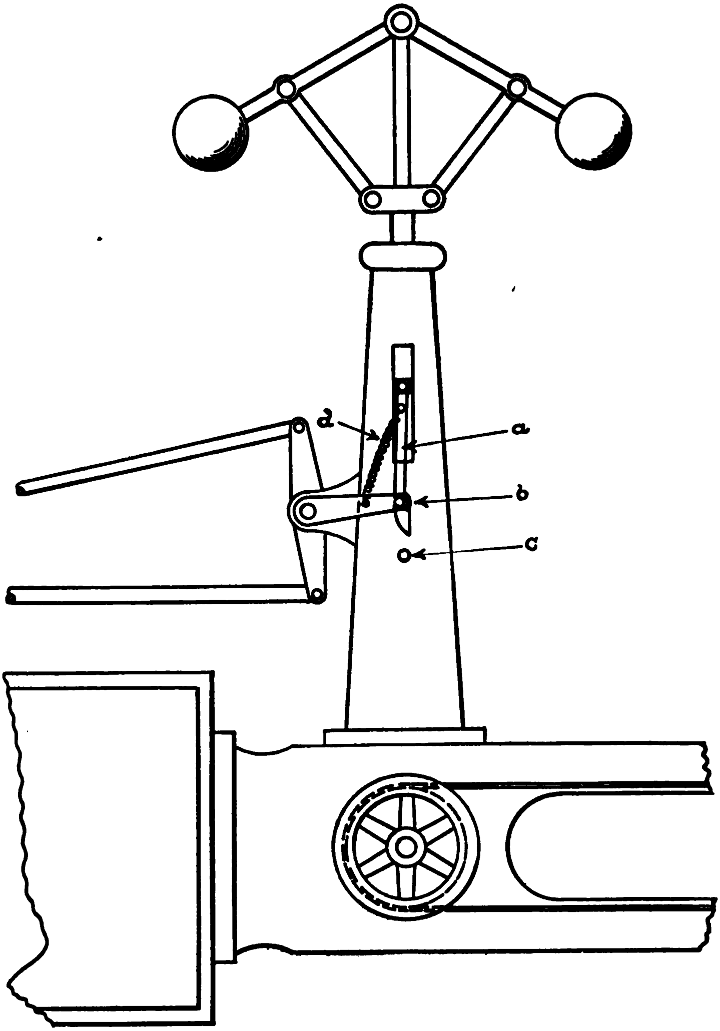


FIG. 7. GOVERNOR SAFETY-STOP

of connection with the rocker-arm. The spring *d* will then come into action and throw the valves so as to shut off entirely the flow of steam.

The load on some engines will occasionally become so heavy that the governor will drop sufficiently low to bring into action the "governor-stop" placed there by

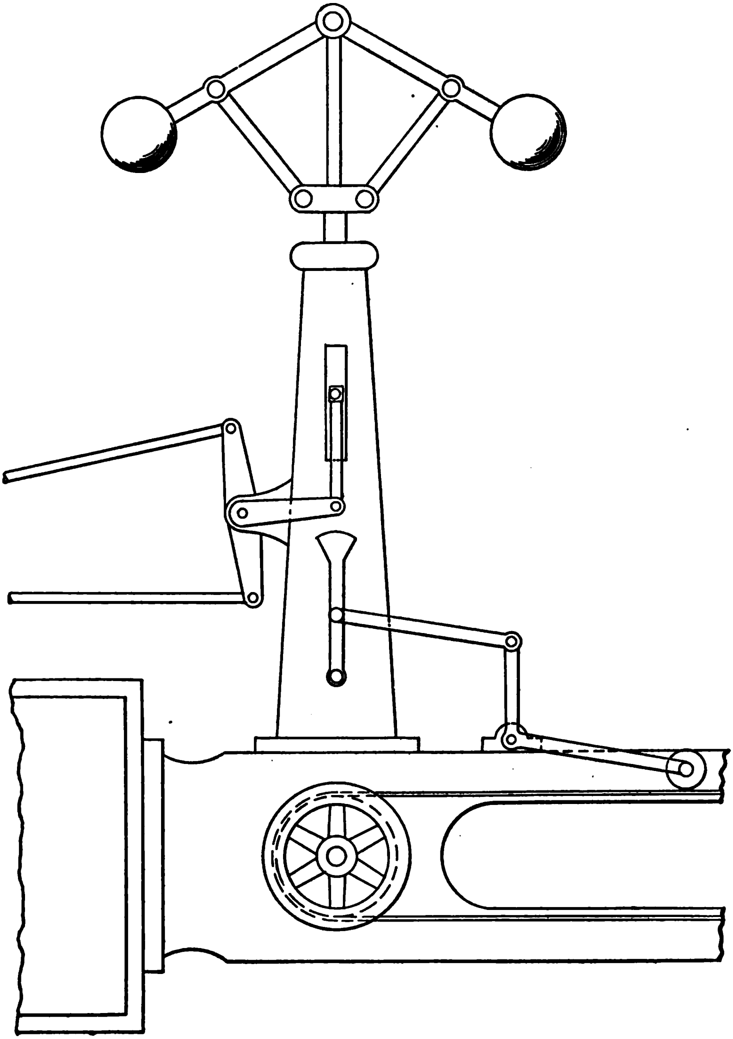


FIG. 8, GOVERNOR SAFETY-STOP

the builder, and thus shut off the flow of steam and stop the engines. This leads some engineers to block up the governor by keeping in position the pin provided for the purpose. This is a dangerous practice and one likely to end in disaster sooner or later. To provide the effect of the pin and at the same time to allow the "breaking-safety" to act in case of necessity, the device shown in Fig. 8 is suggested. The main feature is the idler running on the governor-belt, upon which it depends to hold the "pin" in position.

Fig. 9 shows a stop similar to Fig. 7 except that it is electrically operated. It may be connected with a speed-limit system and operated from any part of the factory.

The utmost vigilance should be exercised to keep the engine in good order and the "breaking-safety" working properly. The safety of the flywheel depends upon keeping the engine within the predetermined speed limit.

Independent Safety-Stops

The failure of the regular safety-devices, placed on the engine by the builder, to prevent flywheel wrecks, has prompted the invention of special safety-stops and speed-limit devices designed to act independently of and supplementary to the regular devices. These special devices undoubtedly lessen the chances of accident and their use is therefore to be encouraged. But it must be borne in mind that they cannot be implicitly relied upon. They consist of complicated mechanism which generally includes an electrical circuit. It is well to attach them to engines, but the vigilance of the attendants should not be relaxed one iota when they are attached.

Care of Independent Safety-Stops

The wires should enter the speed-limit device through an iron-armored conduit, and such a conduit should also be used wherever there is danger of dirt or mechanical injury. Otherwise, on ceilings and walls, it is recommended that the wires be fastened to porcelain knobs or cleats, and that porcelain tubes be used where the wires pass through floors or partitions. Be sure that all electro-magnets, wires, and connections, are free from grounds or liability to ground.

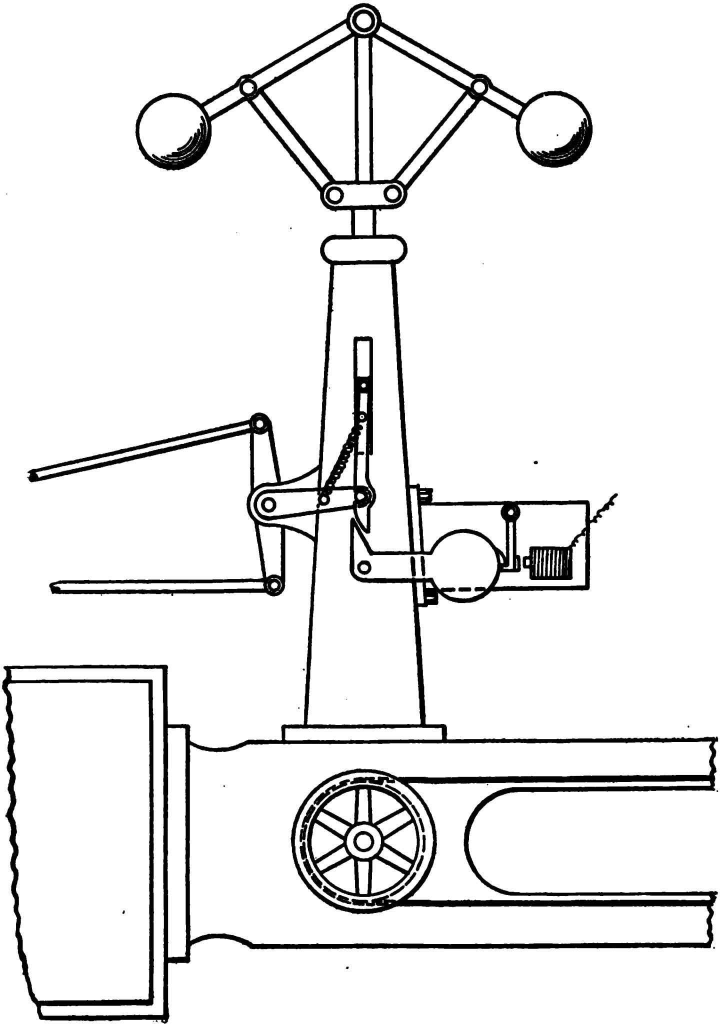


FIG. 9. GOVERNOR SAFETY-STOP

There should be some method of testing all the circuits. This should be done carefully at frequent intervals, and the test should be arranged to indicate weakening of the batteries, as well as a broken circuit. It is also advisable to shut down the engine occasionally by means of the safety-device, and thus be sure that the device is working properly.

It is not uncommon to find the batteries located under or near the main belt. This is an expensive as well as a dangerous practice, for the static electricity from the belt will soon run down the batteries and render them worthless through statically loading their surfaces, with consequent short circuiting. All batteries, therefore, whether wet or dry, should be carefully located outside of the influence of static electricity from belts or other sources.

Wherever a small generator is used instead of batteries, a small "pilot"-lamp should be so wired in connection with it that the lamp will burn whenever the generator is running. This is necessary because it has been found that when a generator runs idle, and only furnishes current when a button is pushed, a glaze will soon form on the commutator that will prevent a flow of current when the circuit is closed. The "pilot"-lamp prevents this by taking just enough current to keep the glaze from forming.

In case of a steam-operated safety-stop, make sure that none of the pipes, cocks, or valves, become clogged. Failure to observe this precaution was the cause of a flywheel wreck recently.

Some Home-Made Safety-Stops

Fig. 10, reproduced from an article in the August 11th, 1908, number of "Power and the Engineer," shows a home-made safety-stop which the author says worked very well. It will be found useful and will make for safety in small factories where the engineer has duties to perform which necessitate his absence from the engine-room. The device consists of an ordinary gate-valve having a stem worked by a lever instead of a screw. This valve is placed on the steam-pipe between the throttle-valve and the main stop-valve in the boiler-room. Referring to the figure, it will be observed that the valve is in an inverted position and is equipped with a long lever. To the end of this lever, which is nearly three feet long so as to make it easy to shut the valve, are fastened lines running to the different rooms in the factory. These lines are preferably of flexible wire rope or good window cord, and are guided by small ground-wheels so as to run easily in any direction. The lines are

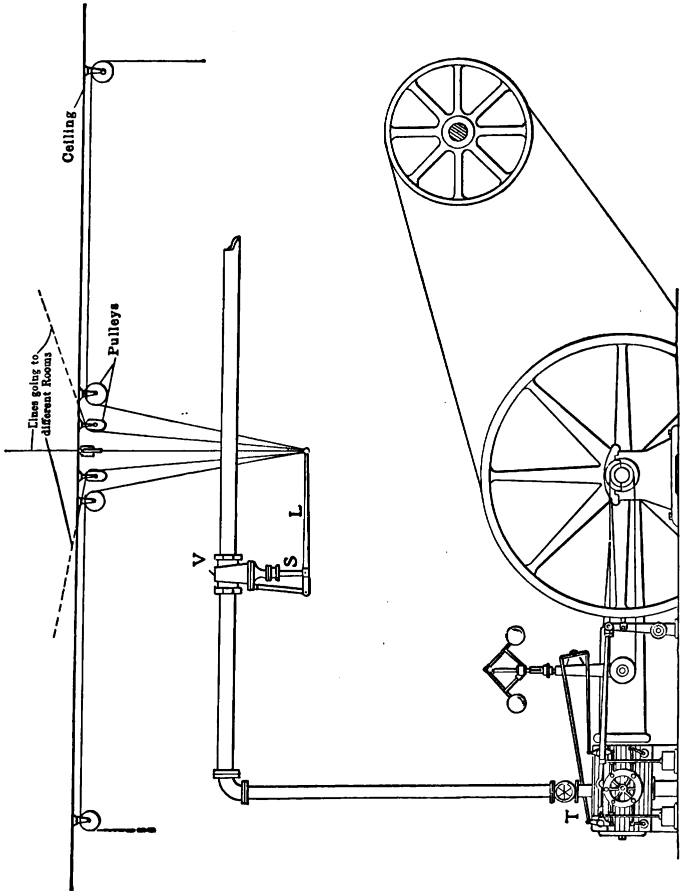


FIG. 10. HOME-MADE SAFETY-STOP

fastened to the end of the lever by means of a ring, another ring being fastened to the other end of each line. When the line is pulled down to shut the valve the ring is slipped on to a hook on the wall, so placed that it will hold the line taut.

Fig. 11 shows an emergency valve,* or a "simplicity engine-stop," as the author of the article calls it, which appeared in "Power and the Engineer" for April 21st, 1908. Six of these valves have been in service since September, 1906, on high-speed engines in one of the largest electrical plants in Columbus, Ohio, where they have been found very reliable. This valve can be closed instantly and positively by a pull on the chain which hangs within easy reach of the engineer (see the cut), usually at one side of or remote from the flywheel. If an engine is disabled, or starts to run away, anyone in the engine-room may cut off the steam quickly by a pull on the chain.

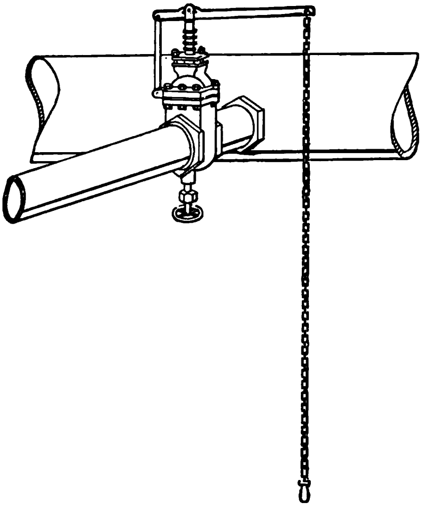


FIG. 11. EMERGENCY VALVE

To quote the remainder of the description,—"The coil spring on the valve-stem just above the stuffing-box is for the purpose of preventing the valve from closing at any time, or if the steam should be shut off the header for any purpose, the spring balances the weight of the gate and lever. The jack arrangement at the bottom of the valve, with a suitable stuffing-box to prevent leakage, will surely and safely open the valve against the steam pressure, after being closed in case of accident.

---

* Patented

"We never expect to lose a flywheel on any of our engines, or a cylinder-head, from an excess of water from the boiler, as long as we use these valves."

Automatic Vacuum-Breakers When condensing engines are liable to be lightly loaded for any length of time, it is especially desirable to provide a safety-device that will break the vacuum when the water rises to a certain height in the condenser. If this is not done, the condenser may be flooded and the engine wrecked, should the speed of the air-pump slacken.

Safety-devices arranged to shut off steam in case the engine starts to "race," should also be arranged to break the vacuum at the same time. Even when the steam is shut off, the vacuum is often sufficient to speed up an engine under no load to the point where the wheel is burst by centrifugal force.

Automatic Circuit-Breakers When electric generators are operated in multiple and driven by separate engines there should be a device that will automatically cut any generator out of the circuit whose engine should start to shut down. This is to prevent it from "motoring" and so running away with the engine.

Inspection of Flywheels Failure of a flywheel usually begins by the starting of a minute crack on the under surface of the rim at the point of greatest stress, viz., near the ends of the arms adjacent to the rim-joint. The cracks gradually deepen until failure occurs with all its disastrous consequences. These minute cracks are visible to an experienced eye, and careful inspection will aid materially in the prevention of flywheel explosions. In wheels built in sections, care should be taken to see that the bolts are properly drawn up.

Inspection of Governors Ninety per cent. of flywheel accidents are due to a failure of the governor-mechanism. The following points should be carefully observed:

1. That the governor-mechanism works freely and does not stick in any way.

2. That the governor-belt is of ample strength, and does not slip, due to oil or other cause. Don't use an old oil-soaked belt.

3. That the governor-pulley or gears are tight on their shafts.

Engines have run away due to a key dropping out of the bevel-gear on the vertical spindle of the governor, or to the loosening of a set-screw on the governor-pulley.

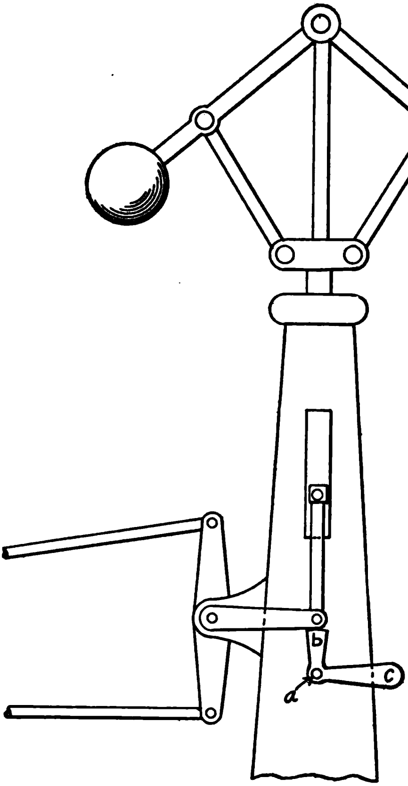
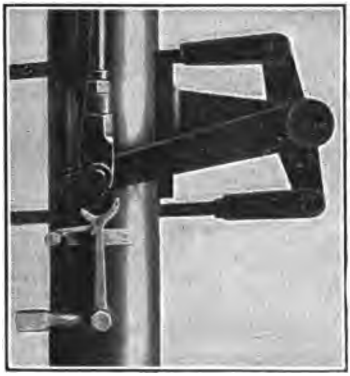


FIG. 12. GOVERNOR SAFETY "STOP-PIN"

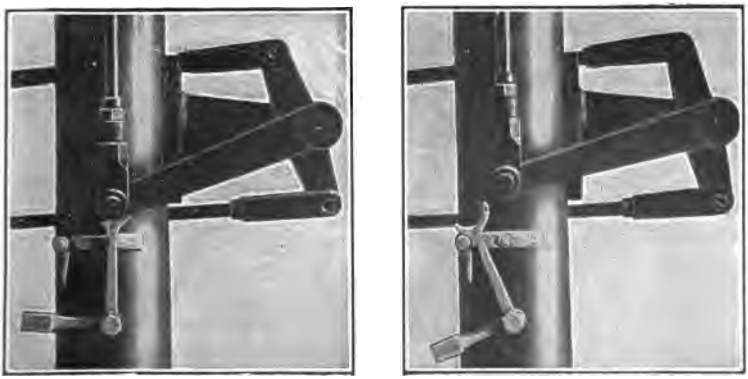
Do not under any circumstances remove or set back the safety-cams or block the governor, so that the governor-stop is made inoperative.

Always remove the stop-pin from the governor-stand immediately after starting up. This precaution is so often forgotten or neglected that the adoption of the simple little device shown in Fig. 12 is strongly recommended. It consists simply of a small lever pivoted to the governor-standard and so balanced that it drops out of place automatically when the momentum of the balls becomes sufficient to lift the governor-rod off it.

A refinement of the same idea which obviates the necessity of the engineer holding the "pin" in place when shutting down, or else of lifting the governor-rod up on the "pin" after the engine has stopped, is shown in Fig. 13. This appeared in "Power and the Engineer"



Position 1



Position 2

Position 3

FIG. 13. GOVERNOR SAFETY "STOP-PIN"

for February 2nd, 1909, from which the following description is quoted:

"The device is very simple and any engineer can make and attach one himself. The illustration shows three positions. The first is that in which the stop is placed just after closing the throttle and before the speed is much reduced. It will be noted that the fork is not directly under the end of the rod that comes down from the collar. As this rod drops, the fork centers, and allows the small dog to drop as shown in the second view. When the engine is again brought up to speed, the rod rises, and the fork is pulled over to one side out of the way by the weighted end as shown in the third view. This leaves a clear path for the rod should anything happen to stop the governor."

Never put heavy grease in the oil-pot of the governor.

Examine all screws at frequent intervals, especially those in the cut-off and safety-cams, to make sure that they do not work loose. The working loose of the lower screw in a cut-off cam sometime ago was the cause of a flywheel wreck.

Be sure the stop-collar of the governor is in such position that steam is cut off when the balls drop near the low limit. Also be sure that when the governor-balls are at the upper limit, the knock-off cams shut off all the steam and do not pass clear under the crab-claw and get caught. This was the cause of a flywheel wreck not long ago.

It occurs not infrequently that the steel toe B (Fig. 14, reproduced from "Power and the Engineer" for April 20th, 1909,) becomes worn down as shown. In order to get the desired trip after the toe B has worn down thus, attendants have been known to shorten the regulator-rod so as to bring down the steel C nearer to B. This practice usually results in throwing the safety-cam or trip D out of reach of the toe B. The danger attaching to such a condition is obvious. If the governor-belt should break, away goes the engine with steam being admitted full stroke, unless perchance the engine is equipped with an independent safety-stop or a "governor-stop," similar to those previously described. The engineer should also make sure that he does not make the safety-trip inoperative by rolling the eccentric ahead, in order to get compression at the end of the stroke.

Be careful that no pieces of rubber gaskets or other material work through the steam-pipe and into the steam-chest of a throttling engine. Wrecks have occurred due to the governor-valve being blocked open by pieces of packing, when a heavy load was thrown off.

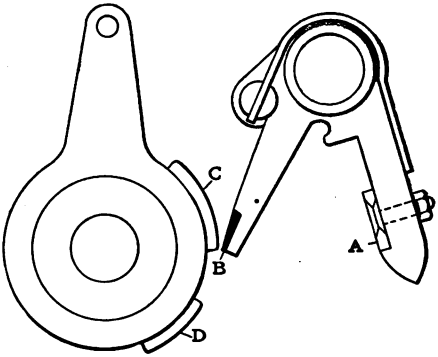


FIG. 14. SAFETY-CAM WEAR

Piston Clearances In making readjustments or repairs to an engine, it is important to look out for the piston clearances. The clearances are so small that every readjustment of the piston or rods must be watched carefully. By the observance of this rule many cylinder-heads will be saved and other dangers avoided.

It is well to keep the clearances at each end as near alike as possible. If any difference is permitted, the clearance at the piston-rod end should be the greater.

It is an excellent plan to have permanent marks on one of the guide-bars to show just what the clearances are. To make these marks, disconnect one end of the connecting-rod, push the piston against the back cylinder-head, and prick-punch or chisel a straight mark across the guide-bar and crosshead; then push the piston against the front cylinder-head and continue the mark on the crosshead across the guide-bar. Then connect up the connecting-rod and turn the engine over by hand.

Whatever the mark on the crosshead lacks of reaching the marks on the guide-bars will be the clearances. In case the piston-rod is screwed into the piston or crosshead, any turn in the screw will make it necessary to re-mark the guide-bars.

Steam Separators It is important from the standpoint of economy that an engine have dry steam. It is further important that no water shall get into the engine-cylinder, as the clearances are small and a very little water getting in may result in a cylinder-head being knocked out. It is always advisable therefore to have a steam separator on the engine supply-pipe, placed as close to the engine-throttle as possible. The most useful separators are those of the receiver-type, that is, having a large volume, preferably six to seven times the volume of the engine-cylinder. These receivers should be riveted steel-drums. A separator of the receiver-type is not only of value in intercepting the moisture in the steam, but also in maintaining an even flow of steam and in providing a reservoir close to the engine, by this means taking up the vibrations due to the sudden stoppage of the flow of steam when the engine-valves close, and preventing these vibrations being transmitted to the piping system. Steam flows in an engine supply-pipe at a velocity of from 5,000 to 6,000 feet a minute, and the alternate starting and stopping of the flow several hundred times a minute is very apt to set up serious vibrations. A separator is also valuable in catching bolts, nuts, etc., carelessly left in the steam-pipes in erecting new work, and thus saving engines and turbines from damage.

Separators are often so badly neglected that they are a menace, rather than a safe-guard, to the engine. Usually the separator is connected with a trap which is intended to drain it automatically, but which is often out of order. All steam separators should be covered with some good insulating material. A separator presents as much surface as a considerable length of steam-pipe, yet it is not uncommon to find separators bare. Gauge-glasses on separators should be considered as important as those on the boilers, yet they are often broken or missing.

Engine Piping and Drains The ends of cylinder or exhaust-pipe drains should be where they can be seen and where they cannot get a water seal. The exhaust-pipe drains should not be less than one-quarter the diameter of the exhaust-pipe. In condensing practice, care should be taken that these pipes do not connect to the condenser or exhaust-pipe at such a place as will make it possible for water to be drawn into the cylinder.

The practice of bringing the drain-pipes from both ends of the cylinder to a tee is dangerous. The reason is that the water forced out of one end may not drop down the tee-connection but be carried by, and up the other pipe into the cylinder in front of the advancing piston.

All steam engines should be equipped with explosion-diaphragms or relief-valves. Pop-valves should be placed on receivers of compound engines to prevent a dangerous rise of pressure due to the high-pressure valve-stem breaking or other cause. The admission of high-pressure steam to the low-pressure cylinder has been the cause of a "racing" of an engine, and an explosion of its flywheel by centrifugal force.

A trap or other means should be provided to remove condensation from the receiver or cross-pipe of a compound engine, and it should be blown out each day in order to be sure that there is a clear passage through it.

Piping in General Steam-pipes should always be of wrought-iron or steel. Cast-iron should never be used for this purpose. The use of copper pipe is also inadvisable.

"Full-weight standard" pipe should be used for pressures up to 125 pounds, and "full-weight extra heavy" pipe for pressures above 125 pounds. Cast-iron "standard" fittings should be used only for pressures below 100 pounds, "medium extra heavy" for pressures from 100 pounds to 150 pounds, and "extra heavy" over 150 pounds. Malleable-iron fittings are better than cast-iron fittings, and cast-steel fittings are better yet.

Steel-pipe bends of long radius are preferable to cast elbows of short radius, as they give the piping system greater flexibility and so enable the expansions and contractions to be borne better, besides which they lessen the vibrations and make the steam-flow easier. It is always best for steam-piping to turn corners by long and gentle curves, avoiding right angles if possible. The pitch of all pipes should be in the direction of the steam-travel.

In making pipe-joints, screwed or threaded joints are suitable only for small pipes and low pressures. For pressures over 150 pounds, joints in pipes less than five (5) inches in diameter may be of the screwed type if the end of the pipe is peened or rolled into a recess in the face of the flange, to prevent leakage and loosening of the pipe in the flange, but joints in pipes of over five (5) inches had best be of the welded type or the Van Stone type, that is, having the ends of the pipe turned or rolled over on the flange.* In the Van Stone type of joint, rolled-steel flanges are preferable to cast-iron or cast-steel flanges. The flanges are loose and slip around on the pipe, which is a great convenience in matching bolt-holes in erecting. All flange-bolts should be long enough to have full threads in the nuts.

Gate-valves are preferable as a rule to globe-valves. Large valves, that is, over 6-inch, should be provided with by-passes. These by-passes will enable the valves to be opened easily by equalizing the pressure on the two sides, will enable steam to be admitted gradually to the cold end of the line and warm it up gradually, thus distributing the expansion stresses more uniformly, and will prevent water-hammer.

All pockets and dead ends should be supplied with drip-pipes so that all condensation can be taken care of. Do not allow any dead lengths of pipe to stand over night with the steam on them, if it can be avoided.

Wherever there is a rise in the main, a drain should be tapped into the lowest point of the main just below the rise. The mains and all important branches should terminate in a drop-leg into which a drain is tapped.

Valves should be so located, if possible, that they cannot form water pockets when either open or closed.

Steam-pipes should be blown out at intervals, to clear them of any debris that may have accumulated in them. In case of any arrangement of piping in which water is apt to pocket, proper drip-pipes should be placed where necessary, and the water kept drained out.

---

*See articles by William F. Fischer in "Power and the Engineer," issue of February 23, 1909, "High Pressure Steam-Piping Systems," and issue of March 2, 1909, "Flange Pipe-Joints for High Pressure."

In continuation, the following quotations are from an excellent article on this subject in "Power" for November, 1905:

"Do not connect the drips with drains or any other place where there is a possibility of stoppage and consequent flooding. Do not connect throttle-drains, separator-drains, and engine-drips, together. Do not connect drains from two separators together, in fact, it is rarely advisable to connect up together any two drips into one line. It is better to run each independently to its own free outlet or trap, or run them independently to a large receiver-tank, which must be effectively drained by a trap or other means. Where the boilers are located sufficiently far below the main steam header and separators to overcome any possible difference of pressure, these may connect to the boilers below the water line, care being taken to see that they are so connected that they will operate properly when one or more boilers are shut down.

"The greatest care should be taken when steam-traps are used to drain steam lines to engines, to see that they are in the best working condition. These traps are placed in steam lines to perform certain work, and when they fail to do this work, they endanger all the machinery on the lines they are intended to drain.

"A valve is a most unsatisfactory method for draining separators, drop-legs, reservoirs, or main headers. This method is dependent entirely upon the memory and judgment of the attendants. It not infrequently happens that where such a method of drainage is in use, the engineer forgets to open the valve, or he may not open it enough."

The use of traps for this purpose is much to be preferred. A trap should always be located where it can be readily seen, and if not of the visible operating type, should be equipped with a water-gauge glass or other indicator, so that the height of the water in the trap at any instant may be observed.

It is always dangerous to attempt to drain off accumulations of water without first shutting steam off the pipe. Water-hammer accidents are nearly always due to opening a drain or engine stop-valve when there is water in the steam-pipe under pressure.

All separators, steam-reservoirs, and drop-legs should be provided with gauge-glasses which should be kept in good working condition.

The advisability of avoiding long steam headers intermediate between the boilers and engines was pointed out in the chapter on boilers and is referred to again here for the sake of emphasis. Direct connections are to be preferred from every standpoint. Steam headers have caused disastrous accidents.

Short and stiff pipes for connections between boilers and engines are also to be avoided. Some engines have enough movement on their beds to cause the breakage of elbows and tees in short and stiff pipe connections. Proper provision for more or less movement should be made. If the engine-room roof is too low to permit the proper disposition of piping, "dog houses" should be arranged so that proper piping may be put in.

Notes on Engine Operation Various precautions to be observed in starting and stopping engines are very concisely set forth in the article in the November, 1905, number of "Power" quoted above. From it the following further quotation is made:

"Engines should under no conditions be started until they are thoroughly heated by blowing live steam through each end alternately, and the steam-pipe and cylinder thoroughly drained of all water; drips should be left open until load is put on and then closed. Many accidents have been caused by simply warming the engine up at one end only. For instance, the engine is placed in a starting position at the cylinder head-end and steam turned on. While the steam is heating the head-end, water collects in the crank-end and remains there. Then, upon starting the engine, this water is trapped in the crank-end.

"In shutting down it is preferable to leave drip-valves closed until the engine is stopped. If the throttle is provided with a by-pass valve it is well to close the throttle and stop the engine with the by-pass. By this means the engine can be brought gradually to a standstill, avoiding the pumping effect of the piston, which occurs when the throttle is closed off entirely. If the throttle be closed quickly, the momentum of the flywheel carries the piston back and forth for many strokes, causing it to act like a pump, so that any water with which the drips connect or water which may be standing in the exhaust-pipe is liable to be drawn into the cylinder and trapped when compression occurs.

"Condensing Engines—Frequently accidents happen to engines through confusion in condenser valves. The safest way is to start the condenser first, which frees the exhaust-pipe and drips of water" (Of course this cannot be done with direct-connected condensers nor with the siphon type of condenser.) (The valve-gear—that of the low-pressure cylinder in the case of a compound engine—must not be in the starting position or the engine may start), "then close the valve in the exhaust-pipe and start the engine non-condensing, exhausting through the relief to the atmosphere, throw on a partial load, and then open the main exhaust to the condenser, when the engine is ready for the full load.

"In the case of high-ratio, and triple- and quadruple-expansion, engines, however, it is often necessary to have the condenser in operation to get started. In such cases, presuming the engine to be warmed up and drained, start the condenser, keeping the main exhaust-valve between the engine and the condenser open. After the condenser has taken care of all water in the pipes and drains, start the engine slowly, giving it plenty of time to reach full speed. After the load is on and the engine is up to full speed, close the drains."

Opinions vary as to the safest method of shutting down a condensing engine. It is good practice to keep the condenser running, but to break the vacuum before stopping the engine. The vacuum is preferably broken by shutting off the injection water, though it may also be broken by opening the atmospheric valve. It is advisable in addition to open the indicator-cocks. Stopping the air-pump before stopping the engine was the cause of a wreck not long ago. The injection water, which should have been carried away by the air-pump, flooded the condenser and exhaust-pipe, and overflowed into the cylinder, breaking cylinder, piston-rod, crosshead, and guide.

When shutting down an engine driving a dynamo in parallel with others, break the connection between the dynamo and the others before shutting off steam on the engine. Otherwise the dynamo may "motor," and accelerate the engine to a dangerous speed.

Never attempt to "bar" an engine around off center, or to pull it off center by grasping the belt, with the steam pressure on. Many serious accidents have occurred due to the sudden starting of the engine, and consequent hurling of the bar or movement of the belt.

Never start to take a piston out of a cylinder without making sure that the throttle- and exhaust-valves are both shut tight and that the drains are wide open. Also try the indicator-cocks to see whether there is any pressure. Fatalities have occurred from neglect of these simple precautions.

Automatic Lubricating Devices So far as possible, engines should be provided at all necessary points with automatic lubricating devices and the attendants thus relieved of the dangerous work of lubricating the various parts one by one. This is particularly important on steamboats and steamships, where a sudden pitch or lurch of the ship may cause the attendant to lose his balance. An attendant in oiling is very liable to be caught or struck by the moving parts.

Lubrication of Air-Compressor Cylinders Recent disastrous explosions in air-compressor systems present striking examples of the danger existing from the use of ordinary engine oil in the air-cylinders of air-compressors. Only a pure mineral oil, with a flash point as high as good lubricating qualities will permit, should be used. As little as possible of even the best oil should be used. *An excessive amount of oil should be kept out of the system.*

Numerous cylinder oils are compounded, and such oils are likely to produce a carbon that will stick the valves, and collect on the valve-faces and other parts of the cylinder and valve-chambers, resulting in a dangerous condition.

Air-receivers are liable to explosion from accumulated oil deposits. Every receiver should be equipped with a pressure-gauge, a safety-valve, and proper drains, and all reservoirs and likely places of deposit in the air line should be thoroughly and frequently drained and cleaned. It is bad practice to have the inlet of an air-compressor take from a hot or dusty room,—the air should be cool and as clean as possible.

The practice of throwing kerosene oil into the inlet of an air-compressor to clean it is an extremely dangerous one, and the cause of an explosion under such circumstances is not difficult to understand. Lubrication of the air-cylinder with soapsuds (preferably made of soft soap, about one part soap to fifteen parts water) for a few hours each week (or less frequently if the load is light), instead of oil, will help very materially in keeping the cylinder clean. The only danger from the use of soapsuds is rust, and this should be overcome by being careful to discard the soap and feed the cylinder with oil an hour or so before shutting down. The receiver blow-off should then be opened and the accumulation of oil and water drained off.

An air-compressor engine should not be controlled by the air pressure alone, as many are, but should be fitted with an auxiliary governor which will act as soon as the speed rises above a certain predetermined limit. This will prevent the engine from "racing," in case an accident to the tanks or piping causes a sudden lowering of the pressure. It is not necessary for an explosion to take place to produce a lowering of the pressure, as the giving way of a pipe, valve, or tank from any cause will have the same effect.

The steel used in the construction of air-receivers should be of the best quality and should have a tensile strength of from 55,000 to 62,000 pounds per square inch. The side seams should be double-riveted, or better still be butt-strapped. The heads should be dished. The larger sizes of receivers should be provided with man-holes. Air-receivers should be subjected to the same tests as heretofore described for boilers under the caption "Hydrostatic Tests" on page 55.

Electrical Apparatus

Dynamos and Motors When operating at a potential in excess of 550 volts, dynamo- and motor-frames and bedplates, ladders, and other metallic parts, should be jointly and efficiently grounded. It is even better to ground all parts whenever the potential is in excess of 250 volts, as there are persons to whom a higher potential is dangerous. Grounding at a less potential than 550 volts is, however, against the rules of the National Board of Fire Underwriters. Whenever machines operated at a less potential than 550 volts are grounded, a permit should be obtained from the Fire Underwriters.

Dynamo- and motor-frames may be insulated from the ground when operating at a potential of less than 550 volts. Better still is a limit of 250 volts within which the machines may be insulated. But if a limit of 250 volts is adopted, care should be taken to get the permission of the Fire Underwriters, as noted in the preceding paragraph.

The rail-fencing about dynamos and motors should be made of some non-conducting material, such as wood. In addition, a high-potential machine should be surrounded by an insulated platform. This may be made of wood mounted on insulating supports, and so arranged that a man must always stand upon it in order to touch any part of the machine. The platform should be covered by a rubber mat, preferably perforated so that oil and water accidentally dropped will not remain on the surface.

The terminals, brushes, connectors, and other parts of high-voltage dynamos, motors, and transformers, should be so arranged or boxed that no person can accidentally establish connection between two parts at a high-potential difference, with his body, clothing, or conducting tool.

Belts in exposed positions where a person's clothing is liable to be caught should be railed or boxed off. Ragged edges of belts should be removed, to minimize the chances of clothing catching.

When a belted dynamo or motor must be set close to a wall, the pulley side should always be next to the wall if possible. This will locate the belt out of the way, as well as make the commutator and brushes easily accessible.

Tools and pieces of iron and steel should be kept away from dynamos and motors while running, as they may be drawn in by magnetism, and perhaps get between the armature and pole-pieces and ruin the machine. Therefore zinc, brass, or copper oil-cans should be used, never iron or "tin" (tinned iron).

Before starting work on any machine not in service, a man should always satisfy himself that the machine is disconnected from the switchboard or circuit.

Oiling and Cleaning In oiling, cleaning, or adjusting any part of a dynamo, motor, or transformer in service, the attendant should wear rubber gloves, first examining them to see that they are in good condition. In making adjustments, especially on high-voltage machines, it is well in addition to stand on an insulated board and never touch opposite sides of the circuit at the same time. The attendant should use one hand only wherever possible. A safe rule is, "Keep one hand in your pocket," in order to be sure not to use it. He should also be careful not to allow any portion of his clothing to get caught in the machinery or belting.

The handles of oil-cans, and wipers and cleaners, should be insulated so that they cannot act as a conductor between the hand and the thing touched.

Rubber Mats Rubber mats or other equally efficient insulating material, kept in a dry and efficient state, should be placed wherever it is possible for an attendant to make an accidental dangerous connection with any conductors, or to be grounded by contact with gas-, water-, or waste-pipes.

Switchboards and Switches Switchboards should invariably have rubber mats or insulated wooden platforms placed in front of them.

All switchboards should have at the back a clear space of at least four feet which should never be used for storage, or otherwise obstructed. This space should be kept closed off, except when making adjustments or repairs.

As far as possible, all work should be done using only one hand at a time. It is best to keep the other hand behind the back, the most dangerous shocks being those from hand to hand. Before touching any portion of a switchboard or its conductors or connections, if the voltage is over 115, the attendant should put on rubber gloves, first satisfying himself that the gloves are in good condition.

In case a circuit-breaker "opens," the attendant should open switch immediately before touching the "breaker," and should see that both are in good condition before making "circuit" again, first setting "breaker," then throwing in switch. It is very bad practice to close a circuit by resetting the "breaker." Any circuit on which the "breaker" opens at short intervals should be investigated, and the trouble located and remedied.

The following simple precautions should also be carefully observed:

Never place any switches in the factory over wet floors or iron floor-plates, or behind running belts.

Screen off "live" sections of high-pressure switchboards from "dead" sections, when working or cleaning has to be done on "dead" portions.

Fuses Standard enclosed fuses should always be used wherever possible. If there is anything amiss, or any fault upon the circuit, the fuses will generally blow at the moment of switching on the current. If the fuses are of the open type, the operator is likely then to receive the full benefit of the explosion of molten metal and the heat of the arc on his hand or in his face. For instance, a fuse may have blown from a short circuit on the line. In attempting to renew this fuse (if an open one), a flash will occur should the short circuit have not been remedied, and burn the operator. Bare metal fuses had best not be used at all, but if used, should be so protected that when they come into operation the fused metal cannot be scattered. In any event, switches and fuses should not be fixed to the same base in such a way that in switching on, the operator's knuckles will touch the bare fuse-metal. The advantages of using enclosed fuses cannot be overemphasized.

Transformers All transformer-cases should be effectually and permanently grounded, and so constructed that in the event of "running to frame," the earth connection will not be broken by the removal of the fuse-box or other part of the case.

Transformer-cases, iron ladders, and all permanent metallic parts contained within the transformer-chamber and not forming part of the electric circuit, should be metallically connected.

All holes in transformer-cases through which high-voltage conductors pass, should be bushed with effective non-conducting material.

All high-voltage connections within a transformer-chamber should be so protected with insulating material that it is impossible to touch them.

Switches for cutting off both the high- and low-voltage connections of transformers should be operated as far as possible from the outside.

All transformers should be periodically inspected. Leads exposed for long periods to the weather are likely to become bare of insulation and come into contact with the case, thus connecting the primary and secondary windings.

Cables and Wiring Overhead cables and wires in factories should be insulated all over, and so supported that there is no possibility of anyone coming into contact with them. The use of exposed or moulded wiring in basements, especially in damp basements, or about rooms having grounded surfaces, such as baths, toilets, and the like, should be avoided.

Very many serious and fatal accidents have been caused by the use of brass-shell key-sockets and flexible cords, accessible to persons from baths, sinks, metal or damp floors, gas-, water-, or waste-pipes, and the like. The use of porcelain sockets in such cases is strongly recommended, provided such use does not constitute a violation of the "Fire Underwriters' Rules." These state that "porcelain-shell sockets being subject to breakage, and constituting a fire hazard when broken, will not be accepted in places where they will be exposed to hard usage."

All dangerous apparatus and cables should be painted *bright red*, and large-type notices prohibiting any unauthorized person going within six feet of them should be fixed in a conspicuous position.

All dangerous parts should be protected against accidental contact, as far as is consistent with convenient operation.

Rubber gloves should be provided by the employer and used on both hands in the handling of cables and wires, whether the parts are "live" or not. The workman should satisfy himself before beginning work that the gloves are in good condition. Working on "live" circuits, especially alternating current, should be avoided as far as is practicable. A man should not work on wire or conductors of any kind with sleeves rolled up or arms exposed, nor should wires ever be handled while standing or sitting in a wet place, without extra precaution to obtain insulation from the ground. In handling any circuit over 115 volts known to be "live," it is best, if possible, to use only one hand. Keep the other in the pocket or behind the back.

If the power has been cut off by opening a switch located some distance from where the work is being done, a sign should always be placed on the switch stating that men are working on the line.

No examinations, repairs, or alterations, necessitating the handling of cables, wires, machines, or other apparatus under high voltage, should be made if it is possible to avoid so doing. In any case such work should be done only by a trained electrician.

Grounding Low-Potential Circuits

The neutral wire of either direct- or alternating-current three-wire systems and one side of an alternating-current two-wire circuit should be grounded, provided (a) that such circuits are so arranged that under normal conditions of service there will be no passage of current over the ground wire, and (b) that the maximum difference of potential between the grounded point and any other point in the circuit does not exceed 250 volts. The "Fire Underwriters" do not permit grounding of a two-wire direct-current system having no accessible neutral point. All ground connections should be made as specified in Rule 13 A of the "National Electrical Code" of the National Board of Fire Underwriters (See end of this chapter where the rule is printed in full).

If alternating-current secondary systems are not grounded, a dangerous, and possibly fatal, shock may be received by anyone touching the secondary wiring if a ground should exist on the high-tension system.

Portable Hand-Lamps Serious, and even fatal, shocks have been caused by the use of faultily constructed hand-lamps. A portable lamp intended for use in places where the person holding it is in contact with earth, such as damp ground, metal plates, or inside steam boilers or metal tanks, should be specially insulated. The two most important points to be observed are: (1) that there shall be no metallic connection between the lamp-holder and any other metal part of the fitting, and (2) that the flexible wires in passing from the lamp-holder shall not be led through a metal tube or otherwise touch any metal part of the fitting.

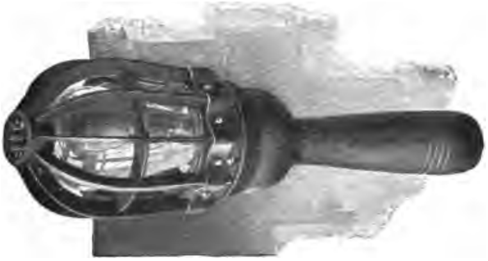


FIG. 15. SAFETY ELECTRIC HAND-LAMP

Fig. 15 shows a "Hand Portable" lamp* (National Electrical Code Standard), now on the market, which has a removable lamp-guard of hard fibre. The porcelain socket is deeply imbedded in the body of the wooden handle, and there are no metal parts to cause short circuits or grounds. It thus offers protection alike to workmen and electrical apparatus.

Fig. 16 shows a home-made lamp. The body is made from a piece of oak about 3½ inches in diameter at one end, and turned down at the other to form a handle.

* Patented

The wires pass through a hole in the center and are clamped near the end of the handle, so that no stress can come upon the connection in the lamp-holder which is of the "batten" type, and is screwed to the flat disk-end. The wire cage is attached by screws to the outside of the disk. There should be no metallic connection between the lamp-holder and the wire cage. The hook shown at the end of the handle for hanging up the lamp should be replaced by a leather or other non-metallic loop, as with constant use it may injure the insulating covering of the flexible wires where it rubs against them.

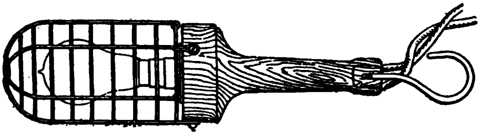


FIG. 16. HOME-MADE SAFETY ELECTRIC HAND-LAMP

"First Aid" in Cases of Electric Shock Emergency outfits* for immediate assistance in cases of electric shock should be provided, and it should be made the duty of some competent person to see that they are kept in good condition. All engineers, electricians, etc., should be familiar with "first aid" treatment for shock, in order to be able to render prompt assistance pending the arrival of a physician. The following precautions and rules for procedure should be borne in mind:

In cases of accident due to contact with a "live" cable or wire, the injured person may retain his grasp on it. If possible, the current should be shut off immediately. If this cannot be done, it is dangerous to seize any part of the victim or his clothes with bare hands. The rescuer should protect his hands whenever possible with rubber gloves, and if the wire is lying on top of the victim, it should be flipped off with a *dry* stick. Where gloves are not available, a coat or other garment, if made into a thick pad, or a thick layer of rags or paper, may be used to pull the victim away from the wire. It is much safer to take hold *only* of his *clothes* rather than to grasp or touch his body. After rescuing him, he should be carried immediately out into the fresh air and placed on his back on a flat surface, with a coat rolled (not folded) under his shoulders and neck in such a way as to allow his head to fall backward far enough to straighten the windpipe. A physician should be summoned at once. The patient's clothing should be loosened, and if breathing is irregular or suspended, artificial respiration should be proceeded with.

---

* These should contain the following articles:
(a) A bottle of aromatic spirits of ammonia.
(b) A bottle of ordinary ammonia with sponge attachment.
(c) A package of bicarbonate of soda (ordinary baking soda).
(d) A tin cup.
(e) A pair of tongue-pliers.
(f) A towel.
(g) A package of antiseptic cotton.
(h) A roll of antiseptic bandaging.
(i) A roll of adhesive tape.

Burns caused by electricity should be treated the same as burns from fire.

Rule 13 A of the "National Electrical Code" of the National Board of Fire Underwriters is as follows:

CLASS B—OUTSIDE WORK

13 A. Grounding Low-Potential Circuits

The grounding of low-potential circuits under the following regulations is only allowed when such circuits are so arranged that under normal conditions of service there will be no passage of current over the ground wire.

Direct-Current 3-Wire Systems

a. Neutral wire may be grounded and when grounded the following rules must be complied with:—

1. Must be grounded at the Central Station on a metal plate buried in coke beneath permanent moisture level, and also through all available underground water and gas pipe systems.
2. In underground systems the neutral wire must also be grounded at each distributing box through the box.
3. In overhead systems the neutral wire must be grounded every 500 feet, as provided in Sections *c* to *g*.

Inspection Departments having jurisdiction may *require* grounding if they deem it necessary.

Two-wire direct-current systems having no accessible neutral point are not to be grounded.

Alternating-Current Secondary Systems

b. Transformer secondaries of distributing systems should preferably be grounded, and when grounded, the following rules must be complied with:—

1. The grounding must be made at the neutral point or wire, whenever a neutral point or wire is accessible.
2. When no neutral point or wire is accessible one side of the secondary circuit may be grounded, provided the maximum difference of potential between the grounded point and any other point in the circuit does not exceed 250 volts.
3. The ground connection must be at the transformer or on the individual service as provided in sections *c* to *g*, and when transformers feed systems with a neutral wire, the neutral wire must also be grounded at least every 250 feet for overhead systems, and every 500 feet for underground systems.

Inspection Departments having jurisdiction may *require* grounding if they deem it necessary.

Ground Connections

c. When the ground connection is inside of any building, or the ground wire is inside of, or attached to any building (except Central or Substations) the ground wire must be of copper and have an approved rubber insulating covering, National Electrical Code Standard, for from 0 to 600 volts. (See No. 41.)

d. The ground wire in direct-current 3-wire systems must not at Central Stations be smaller than the neutral wire and not smaller than No. 4 B. & S. gage elswhere. The ground wire in alternating-current systems must never be less than No. 4 B. & S. gage.

On three-phase system, the ground wire must have a carrying capacity equal to that of any one of the three mains.

e. The ground wire should, except for Central Stations and transformer sub-stations, be kept outside of buildings as far as practicable, but may be directly attached to the building or pole by cleats or straps or on porcelain knobs. Staples must never be used. The wire must be carried in as nearly a straight line as practicable, avoiding kinks, coils, and sharp bends, and must be protected when exposed to mechanical injury.

This protection can be secured by use of an approved moulding, and as a rule the ground wire on the outside of a building should be in moulding at all places where it is in within seven feet from the ground.

f. The ground connection for Central Stations, transformer sub-stations, and banks of transformers must be made through metal plates buried in coke below permanent moisture level, and connection should also be made to all available underground piping systems including the lead sheath of underground cables.

g. For individual transformers and building services, the ground connection may be made as in Section *f*, or may be made to water piping systems running into buildings. This connection may be

made by carrying the ground wire into the cellar and connecting on the street side of meters, main cocks, etc.

Where it is necessary to run the ground wire through any part of a building it shall be protected by approved porcelain bushings through walls or partitions and shall be run in approved moulding, except that in basements it may be supported on porcelain.

In connecting a ground wire to a piping system, the wire should be sweat into a lug attached to an approved clamp, and the clamp firmly bolted to the water pipe after all rust and scale have been removed; or be soldered into a brass plug and the plug forcibly screwed into a pipe-fitting, or, where the pipes are cast-iron, into a hole tapped into the pipe itself. For large stations, where connecting to underground pipes with bell and spigot joints, it is well to connect to several lengths, as the pipe joints may be of rather high resistance.

Where ground plates are used, a No. 16 Stubbs' gage copper plate, about three by six feet in size, with about two feet of crushed coke or charcoal, about pea size, both under and over it, would make a ground of sufficient capacity for a moderate-sized station, and would probably answer for the ordinary sub-station or bank of transformers. For a large central station, a plate with considerably more area might be necessary, depending upon the other underground connections available. The ground wire should be riveted to the plate in a number of places, and soldered for its whole length. Perhaps even better than a copper plate is a cast-iron plate with projecting forks, the idea of the fork being to distribute the connection to the ground over a fairly broad area, and to give a large surface contact. The ground wire can probably best be connected to such a cast-iron plate by soldering it into brass plugs screwed into holes tapped in the plate. In all cases, the joint between the plate and the ground wire should be thoroughly protected against corrosion by painting it with waterproof paint or some equivalent.

479726

Elevators

Guards on Car Passenger elevators should invariably be roofed over, and the sides, other than the side used for entrance and exit, should be cased in. Freight elevators should have a grating or other form of protecting guard over the top of the car, and the unused sides of the car should be boarded up to a height of at least seven (7) feet, or guarded by substantial wire screening of sufficiently close mesh to prevent a hand or foot passing through. These precautions will prevent injury from falling objects, and will prevent the feet of the passengers or of the operator being inadvertently thrust over the edge of the car. The most frequent accidents in the case of freight elevators are injuries to feet projecting over the edge of the car.

When a passenger elevator has more than one entrance and exit, both openings should be equipped with doors or folding-gates, and the door not in use at any given moment should invariably be kept closed.

When more than one side of a freight elevator is used for entrance and exit, a wide bar should be kept in place across the side not in use at any given moment. Probably the best plan is to have the bar hinged or pivoted at one end and dropped into a socket at the other.

Many elevators are equipped with an operating-lever which rises about two and a half feet above the floor. There is a latch which drops into a slot in a sector when the lever is in its central position. This latch is provided for the purpose of preventing the lever from being moved until the latch is released. It sometimes happens, however, that the operating-apparatus gets out of proper adjustment, so that when the elevator is stopped the lever stands not at the center but at one side, or that the latch-spring does not work, in either of which cases the latch fails to catch. The lever is thus free to move if the operator releases his grip on it. If, under these conditions, the operator takes his hand off the lever when the elevator stops and a passenger brushes against the lever, forcing it over, the car will at once shoot up or down as the case may be, causing a severe, and perhaps fatal, injury to anyone entering or leaving the car. This defect should be remedied immediately upon being discovered. In the case of freight elevators there is even greater danger of accident from this cause, as in most cases the man who operates the elevator assists in loading and unloading, and material placed on the car is apt to fall against the lever and start the car. To prevent accidents of this character, the operating-lever should be surrounded by a sheet-metal guard. Wire netting or wood may be used, but sheet-metal is much to be preferred, because more substantial.

Protection of Elevator Shafts

The shafts of all elevators should be securely guarded. In the case of passenger elevators in *fireproof* buildings, the guards should consist preferably of metal grille-work forming an enclosure which should be at least seven (7) feet high, or better, extending from the floor to the ceiling, particularly if a stairway winds about the shaft. But in any event the space opposite to the travel of the door in the car should be completely guarded from the floor to the ceiling, in order to afford greater security to the passengers riding past in the car. The enclosure for freight-elevator shafts in *fireproof* buildings should consist preferably of metal grille-work or substantial wire screening at least five and a half (5½) feet high, though seven (7) feet is better, but it may consist of a framework of wooden pickets of the same height. The openings in the grille-work, the mesh of the screening, and the space between the pickets, should be sufficiently small to prevent a hand or a foot passing through. In *non-fireproof* buildings, the elevator shafts and the shaft-doors should be constructed fireproof preferably, the shaft either of brick or of metal-framing filled in with hollow brick and carried up solid from floor to ceiling, and the doors when closed filling the opening to the shaft completely. Any lights in the shaft or doors should be provided with wire-glass, and no pane of wire-glass should have an area exceeding five (5) square feet. Such fireproof shafts are required by law in some cities, but it is an ideal that current practice realizes but rarely as yet.

The shaft-doors of passenger elevators should consist preferably of sliding-gates of metal grille-work with openings small enough to prevent a hand or foot passing through. These gates when closed should completely fill the door-opening into the shaft. The shafts of freight elevators should have gates at each floor sufficiently high to prevent anyone looking over them, and with the spaces between the bars narrow enough to prevent anyone putting his head between them into the shaftway. These gates should be at least five and a half (5½) feet high. When gates of the lifting type are less than 5½ feet high, they should be built up to that height by the addition of sheathing or wire mesh, wherever the height of the ceiling will permit. The sheathing or mesh may be simply stretched over a frame screwed on the upper part of the gate. When a lifting-gate cannot be 5½ feet high on account of a low ceiling, it may be made in two parts that telescope, or a sliding-gate or a vertical collapsing-gate may be used.

The best practice is to use gates that can only be opened *from the inside* of the shaft by the operator. Gates that can be opened from the outside are often the cause of serious accidents. Whenever it is found that a gate may be unlocked from the outside by reaching the hand or an instrument through it, this should at once be made impossible by means of a guard consisting of a piece of sheet-metal fastened to the gate over the latch or bolt.

In the case of freight-elevator shafts, the gates should be preferably of the semi-automatic type, i. e., arranged to drop into place or to close automatically when the elevator leaves the floor and to remain locked until unlocked by the operator. In any event, *the gates should always be kept closed when not in use and when the car is not at the given floor.*

Gates are greatly to be preferred to bars or chains across the shaft-opening, as the latter permit a person to thrust his head into the shaft,—a prolific source of fatal accidents. Bars and chains are also more likely to be left out of place than are gates. Under no circumstances should a gate be wedged or propped up.

Doors or gates that can be seen through are much to be preferred to solid doors. In the case of doors that cannot be seen through, the words—"Elevator. Danger." —should be painted on them in large *red* letters.

Wherever floor-tracks are used, they should be countersunk.

Unless supplemented by a gate, bar, or chain, between them and the shaft, upright hinged swinging doors should not be used, because of the facility with which they are fastened back and left open.

Trap-doors in the floor are excellent devices, but should always be supplemented by gates or guard-rails on all sides.

Frequently on the lower floors of buildings, an open passageway is left under the elevator shaft. This is very bad practice and should be avoided wherever possible. Where it cannot be avoided, the space should be carefully guarded, and the guards kept in place to prevent any one getting under the descending elevator.

All elevator shafts and landings should be well lighted. Painting the sides of the shaft white, will be found to help wonderfully.

In the case of elevator cars that are not enclosed, all projections in the elevator shafts, including sills, door lintels (if the doors are not flush with the side of the shaft), beams, the tops of window recesses (unless covered with wire netting flush with the shaft), etc., should be beveled with sloping boards or sheet-metal. Such boards or metal should be fitted directly under the sill, lintel, or other projection, so as to push any projecting portion of the body back into the car instead of crushing it. In the case of enclosed cars this should be done for that side of the shaft (or the two sides if the car has a rear door) past which the car door travels.

A clearance of at least three (3) feet should be left at the top and bottom of the shaft between the top and bottom of the car, respectively, when the car is at the highest and lowest points of its travel. This will greatly lessen the chance of crushing anyone between the car and the top or bottom of the shaft.

Where elevators run in an open shaft, i. e., one not guarded by a vertical enclosure, they should be securely fenced by doors or other means, to prevent persons or goods from falling out. In addition, the car should be provided with a gong that will ring continuously while the car is descending.

Overhead Gratings At the top of the shaft and under the suspension sheaves and beams, there should be a substantial working grating. This is necessary to permit safe inspection of the sheaves, and to prevent any tools or broken parts falling down the shaft.

Sidewalk Elevator Protection A guard should be placed at the first floor or street level. If the platform runs to the street level, the opening resulting from the hatch-doors being open should be guarded by chains or bars. If the elevator runs inside the building, the sides of the hatch should be guarded by an enclosure at least three (3) feet high.

All upper head wheels should be cased over, to prevent any possibility of the load getting against the wheels on either side and locking them, and so causing the elevator to tip.

Some Simple Elevator Warnings A very efficient device to warn a person looking into the shaft, of a descending car, consists of pendant chains fastened to the bottom of the car. These act the same as a low-bridge signal on a railroad. Ordinary brass or dog chain will serve the purpose perfectly. These chains should be about five (5) feet long and fastened about five (5) inches apart as near the edge of the car as possible. In some cases it may be found convenient to screw a piece of angle iron, as long as the elevator is wide, to the bottom of the car, with holes drilled in it at proper intervals to receive the chains.

To avoid accidents due to any part of the body projecting over the sides of an open freight elevator, fasten a strip of wood about ¾ or ⅞ inch square across each door or other opening about a foot from the top and flush with the walls, so that the floor of the car passes close to it. The strips are not strong enough to injure a person but will cause him to draw back quickly and may be the means of preventing a badly injured head or a crushed foot. The sticks may sometimes be broken in other ways, and one man should be held responsible for their immediate replacement.

These devices, however, must be regarded as little better than makeshifts. It is far and away better so to guard the shaft that a person cannot thrust his head into the path of a descending car, and so to guard the car that a person's foot cannot project over the edge of the car.

Elevator Safety-Devices

All passenger cars suspended by cables should be equipped with a "speed-governor safety-device." Such a device will stop a car, if, from any cause, it should run away. Running away may be caused in a variety of ways, but less danger is to be apprehended from the breaking of the cables than from some derangement of the mechanism which permits the car to attain a dangerous velocity. The speed-governor is provided to throw the safety-device on the car into action when the car has reached a predetermined speed. Necessarily the speed-governor must be set to operate at a speed somewhat in excess of the normal speed of the car, else it will interfere with the running of the car. Thus, if a car runs normally at a speed of 250 feet a minute, the speed-governor can be set to cause the safety-device to act when the car reaches a speed of say 400 to 500 feet a minute. The design of these devices should of course be such as to arrest the descent of the car with the minimum shock, in order to save the passengers from injury.

As a general rule, a speed-governor safety-device is not required on a plunger elevator, owing to the improbability of the car dropping.

All freight elevators should be equipped with a "breaking safety-device." Then, if the cables break, the springs will cause the device to grip the guides and stop the car. But it is advisable that a speed-governor safety-device be attached also. One of the most frequently disastrous causes of freight-elevator accidents is the breaking of the gearing in connection with the winding-drum. This releases the drum and allows the car to fall, pulling the cables with it. Often the tension in the cables, due to the friction of the winding apparatus, is sufficient to keep the breaking safety-device from operating. In this case the speed-governor safety-device would be brought into action and thus prevent a free fall. If the cables should break between the car and the drum, the breaking-safety would operate then also.

Safety-devices should be examined at regular intervals to make sure that they are in perfect working order. In the case of a breaking safety-device, it is usually only necessary to block the car so as to get slack cables, and then test to see that the safety holds. In the case of a speed-governor safety-device, a careful examination of the governor and the various other parts of the device will generally show with a fair degree of certainty whether the device will act in case of necessity. If any doubt exists on this point, however, a running test should be made.

Wherever practicable, an elevator should be equipped with a check-rope (i. e., a centering rope) to throw the power off and the brakes on, in order that the operator may stop the car in case the hand-rope breaks.

Care of Safety-Devices Inspect the safety-devices at least once a week, and do not let them get gummed up with grease. If the safety-wedges are thrown in without apparent cause, it may be due to dirt on the guides or to weakness of the springs. Guides are often so dirty that the springs cannot well prevent the wedges catching. Where a weighted sheave is used on the governor-cable at the bottom, see that the weight does not rest on the ground, as this will slacken the cable or throw it off the sheave.

In order that the safety-governor shall be reliable, it is necessary that the governor-rope shall be in just as good condition as the other ropes. The failure to inspect this rope properly, and make sure that it is at all times in perfect condition, has been a frequent cause of accidents.

Jaws or wedges of safety-devices should be kept clean and in proper adjustment, for effective operation.

Elevator Shaft-Doors and Car Interlocking-Devices In some places, notably in Rhode Island and in cities of the first class in Pennsylvania, it is required by law that the shaft-doors of passenger elevators shall be equipped with an interlocking-device which will prevent the elevator car being moved until the doors are securely closed. In our opinion the use of these devices is inadvisable. Unconsciously the elevator operator will get to rely on them and become careless in the handling of the controlling-device, whether hand-rope, lever, or switch, when the car is stopped at a floor. Sooner or later will come a time when the interlocking-device is out of order, and a careless or inadvertent movement by the operator will operate the controlling-device and start the car when passengers are getting on or off, and a serious accident may result. Or it may happen that through some derangement of the machinery, the car will start while the controlling-device is still locked by an open door, and it will not be within the power of the operator to stop the car. It is true that in many cases an emergency switch is provided for just such contingencies. But it should be borne in mind that this switch will be used very seldom, and that consequently it will be in all likelihood the last thing that the operator will think of when a crisis arises. It is better to have the car at all times under the absolute control of the operator, and the operator fully imbued with the sense of responsibility consequent upon that control.

While an interlocking-device is useful in training an operator always to close the shaft-doors before he starts his car, this in our opinion cannot compensate for the car being to a greater or less extent out of control of the operator in case of accident when a shaft-door is open.

Elevator Locking-Devices It is sometimes desirable under certain conditions to provide a device to lock a freight elevator, when stopping at a given floor, so that no person on another floor can start it. These devices are as a rule only applicable to an elevator operated by a straight hand-rope. There are several of these devices on the market. A brief description of two of them follows.

The use of these or other similar locking-devices is not advisable, however, on elevators running over 250 feet per minute. *Under no circumstances should such locking-device be used in stopping the car*, but only to lock the car, if desired, after it has been brought to a standstill in the usual manner.

In the first device,* Fig. 17, the lock is mounted upon a pipe-standard through which the operating-cable passes. Pairs of lugs are secured at certain positions on the cable so as to come into contact with the lock at each floor level. By the use of a key which is supplied with the lock, the cable may be secured to the car in such a manner that it cannot be moved except at the will of the holder of the key. The maker states that any tendency on the part of the car to creep will be counteracted by an equal movement of the cable. Another advantage is that when the lock is on, it is impossible to operate the car from any position other than within the car itself.

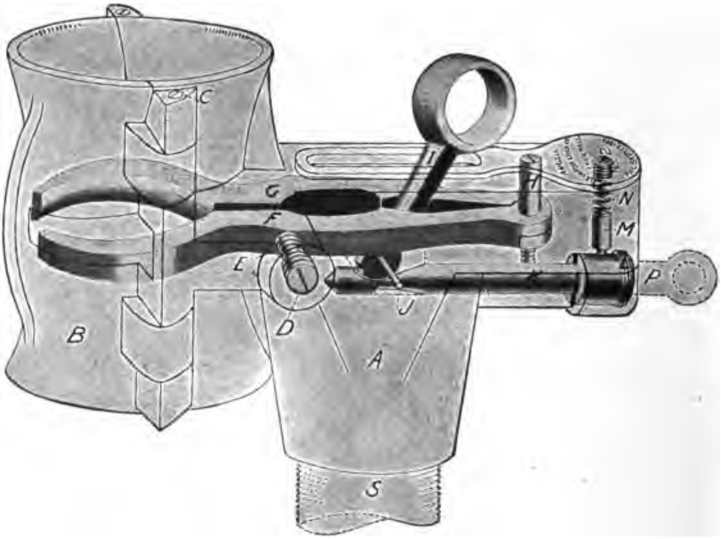


FIG. 17. ELEVATOR-LOCK

Another locking-device,† Fig. 18, is operated by a slight pressure of the foot on a pin passing through the floor of the car. This releases the cams which hold the cable and the car may then be started as usual. The foot must be kept on the pin during the movement of the car. When leaving the car, the foot-pin may be removed, and the car is then safely locked. The maker of this device also states that it counteracts any tendency of the car to creep. Employees should never be permitted to put a weight on the pin of this lock to hold the pin down.

---

* Patented
† Patented

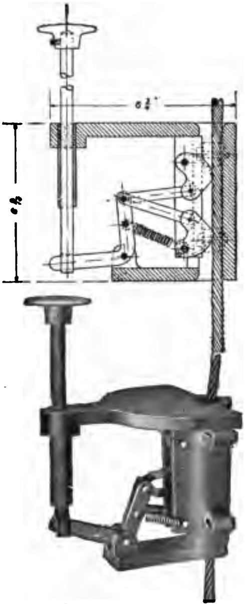


FIG. 18. ELEVATOR-LOCK

Automatic or Self-Closing Doors Automatic, or self-closing, doors are occasionally used on passenger elevators. By pulling a chain or touching a button, a spring or compressed-air mechanism is released, and the door closes automatically. In our opinion the use of these devices is inadvisable. The operator is prone to release the door as he starts the car, and as the door is apt to close more rapidly and with greater force when closed by automatic mechanism than when closed by hand, the passengers are more liable to be caught and injured.

Conditions of Use of Elevators Elevators should never be used indiscriminately by a number of persons. It often happens that, unknown to the operator (if there be one), or other person running the car for the time being, the car is set in motion by other persons from other floors, with the result that the former, having left the car and returning with the expectation of finding it still in the position in which he left it, falls down the elevator shaft. (It should be remembered that heavy cases, hampers, and other goods, are often placed in the elevator by persons walking backward and pulling the goods in after them). Similar accidents may occur with hydraulic elevators, owing to a leaky valve or piston, the car creeping away from the floor or landing when left for a short time. If the hand-rope is provided with a locking-grip, the creeping of the car will automatically open the valve and the car will be restored to its former position.

Rest for Safe-Lifting Elevators Where safes or other exceptionally neavy articles are handled, the car should be provided with a device to support it independently of the cables or plunger while loading and unloading. Otherwise the car may jump up when the safe is partially removed from it, and cause the safe to fall forward on the men handling it. Similarly the car, if not supported, may jump down when it is being loaded.

Car-Locking Device Wherever small cars are run in on an elevator, as in gas works, chemical works, etc., a device to hold the car immovable on the platform while the elevator is in motion is a necessity. A very good one as applied to a Hunt car at the gas works of the Rochester (N. Y.) Railway and Light Co. is shown in Fig. 19.

Elevator Cables The most serious deterioration in wire in rope is due to the constant bending over sheave-wheels or drums when under stress. This deterioration increases with increase in the speed or load. To increase the work done, it is better to increase the load rather than the speed. Increase in speed wears out a cable more rapidly than increase in load.

Cables should lead as straight as possible, avoiding the use of idlers. The sheaves should be arranged so that the cables in their travel will always be bent in the same direction and bear on the sheaves on the same side. A cable will break very quickly if passed over one

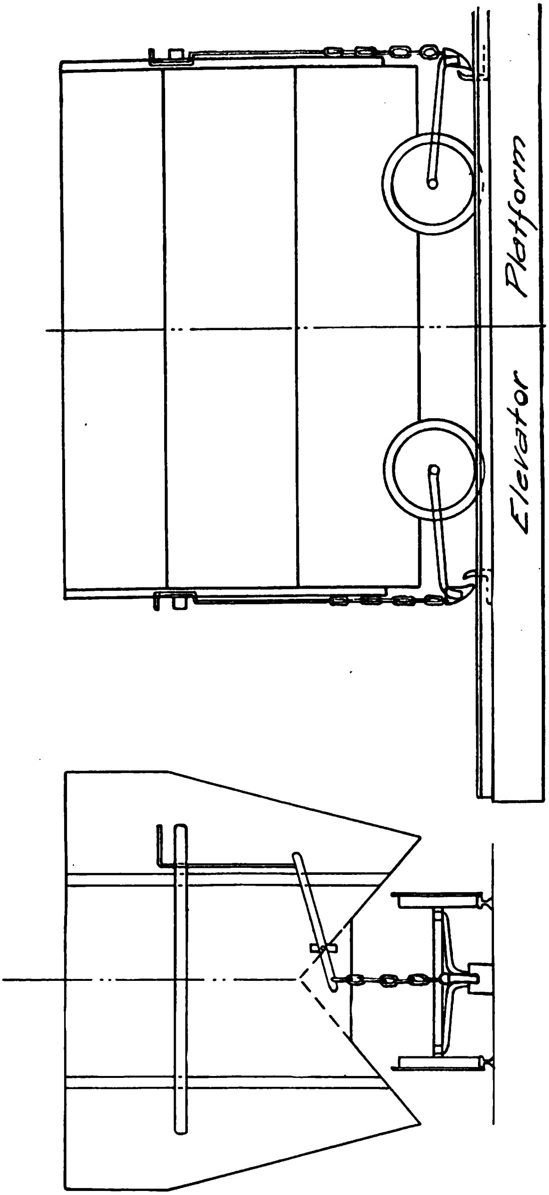


FIG. 19. CAR-LOCKING DEVICE

sheave and under another, the effect produced in this way being precisely the same as that produced by bending a wire forward and backward in the hands. Great care should be taken to have the grooves of drums, sheaves, and pulleys, perfectly smooth and of proper size to accommodate the cables, being neither too small nor too large. Drums, sheaves, and pulleys, should be in perfect line with the cables, so that the cables will not chafe and wear on the sides of the grooves.

The highest efficiency in a cable is denoted when abrasion of the wires so occurs that they are worn nearly half through before fracture takes place. The length of time that it will take for the wires to wear half through will depend of course upon the amount of work the cable is called upon to do. Under usual conditions of passenger or freight service, a cable should last two years before the wear will require it to be replaced.

If, on the contrary, the wires break square off before abrasion has taken place to any extent and the cable has been in service but a short time, the efficiency is very low, and the cable should be replaced by a new one immediately. The breaking of the wires in this way is often due to the ropes being bent around sheaves of too small diameter, or to the grooves of the sheaves being too narrow so that the rope is cramped, or too wide so that the rope flattens out.

All standard lifting- and counter-weight-cables are composed of six strands of nineteen wires to the strand, wound about a hemp center. Occasionally cables of fewer wires to the strand are wrongly selected and, having less flexibility, deteriorate more quickly.

It is not necessary to replace a cable the moment the wires begin to show wear, but when wear occurs, the cable should be inspected carefully thereafter at regular intervals, even though only a few wires are broken. Later, when the wires begin to break rapidly, a sharp watch should be kept on the cable and just as soon as fifty per cent. (50%) of the wires in several adjacent strands are broken, the cable should be discarded. The rule should be not to use a cable further after it has lost half its strength. Moreover, when many wires are broken, such wires may separate from the cable in bending over the sheaves and drum and become entangled with other cables, causing the cable or one of its fellows to be pulled out of its prescribed running path.

Sometimes the wires of cables begin to break on the inside of the cable first. This condition will be detected by noting broken wires down in the lay of the rope, or in other words, down in that part where one strand becomes covered by the one lying beside it. When this occurs, no chances should be taken, but the cable should be discarded, as it is impossible to tell how many such breaks there may be. It is entirely possible that the wires in all the strands have broken on the sides toward the inside of the cable. As the exact condition of the cable cannot be determined, the safe course should be followed, and a new cable substituted.

Tiller-ropes, which are extensively used for hand-ropes, are composed of six strands, forty-two wires to the strand, wound about a hemp center and with a small hemp center in each strand, making seven hemp centers in all. The condition of a hand-rope can best be judged by passing the hand over it, when, if the rope feels very rough, it is sufficient evidence that the wires are broken to such an extent that the rope should be replaced by a new one.

Wire rope requires lubrication just the same as high-speed journals, or other rubbing surfaces. Conditions often prevent the proper treatment, but to insure the best results the rope should be thoroughly lubricated when the strands are being laid up in the rope. Afterwards the rope should be kept well saturated with a lubricant that is free from acid. After bending a new cable on a car, it is well to go over it with a heavy coat of raw linseed oil or a mixture of graphite and cylinder oil. This will soak into the center, and so make amends for what possibly was not done when the strands were laid in the rope. For an outside lubricant, a mixture of graphite and cylinder oil gives the best results.

Failure of ropes is attributable to one of three causes,—(1) crystallization in the wire, (2) internal cutting or mutual abrasion of the wires, or (3) external wearing or abrasion incident to use. The first cause of failure occurs most commonly in cables that have been in use for some time. It is difficult to detect in its early stages. The second and third causes are responsible for the majority of failures of ropes.

The tensile strength of the steel used in elevator cables varies from 90,000 to 100,000 pounds per square inch. Owing to the peculiar wear to which a hoisting-cable is subjected, it is necessary to use a high factor of safety. A factor of from 6 to 7 should be used in the case of new cables. When the cables have deteriorated through use, this factor should be increased. Sometimes it is necessary, even when the cables are new, as, for instance, when the speed of the cables is excessive, to use a factor of safety of from 8 to 10. With a factor of safety of 6, therefore, the working load of a steel cable, the metal of which has a cross-section of one square inch, is 15,000 pounds, and with a factor of 10, it is 9,000 pounds.

It is not uncommon to find only one lifting-cable on a freight elevator. The use of two or more is much safer, and is much better practice. It is not wise to rely too much on the breaking safety-device.

Frequently one or two of the lifting-cables will crack and wear badly while the other cables remain in good condition. In such cases far more satisfactory results will be obtained if *all* of the cables are replaced by new ones, instead of simply the defective ones. When all the cables are renewed, they will stretch evenly. The same course should be followed in the case of the counter-weight-cables.

On some elevators the lifting-cables are connected to a cable loop running from the girdle or crosshead of the car to the safety-plank. When the cables of such elevators are inspected, this loop should be carefully inspected also, and if it is necessary to renew the lifting-cables it is advisable to renew the loop also, particularly if it has been in use for some time. While there is not much wear on this loop, its renewal under the stated conditions is the best practice. The cost of renewal at the same time that the main lifting-cables are renewed is but trifling.

Care should be taken to see that each cable is independently fastened to the car and to the counter-weight. Cases will occasionally be met with where the counter-weight-cable is passed around a cast-iron roller at the crosshead of the counter-weight and the two ends of the cable are made fast to the top of the car, thereby apparently making two counter-weight-cables, whereas in effect there is but one. When a cable so fastened breaks at any point, there is obviously nothing left to hold the weight, unless perchance a lug has been fastened on the cable on each side of the roller, or the roller has been made in the form of a cam. But even when these lugs are provided or the roller-cam is used, if the cable breaks where it passes around the roller, as experience has shown that it is very likely to do, there is nothing left to hold the weight. Wherever cables are connected with a roller in the manner described, the connection should be changed and each cable connected separately to the crosshead of the counter-weight, so that, in the event of one cable being cut out or breaking, the other cable will hold the load. Such a change should not be made, however, on any elevators of the "Graves" type, or where the change will interfere materially with the operation of the safety-device.

Where two counter-weights run in the same slide so that the cables carrying the lower one pass by or through the upper weight, as is the case with most electric elevators, serious accidents have occurred due to the continued chafing and eventual breaking of the cables. To guard against this, the lower counter-weight-cables should be covered with pipe-sleeves placed on and fastened to them. These sleeves should extend the full height of the upper counter-weight and a little over, so that the pipe-sleeve will move with the cable and take the wear and chafing that would otherwise come on the cable.

Both lifting- and counter-weight-cables of a drum-machine elevator should have at least one full turn of cable on the drum when the car is at the lowest and highest points of its travel, respectively.

Lifting- and counter-weight-cables should not be spliced under any circumstances. Hand-ropes may be spliced, using the proper connections especially designed for the purpose.

All water and moisture should be kept from elevator cables, as the deterioration due to corrosion is very rapid.

Wire rope should never be taken off over the head of a reel. The reel should be jacked up on an axle and revolved as the wire is unwound, or should be rolled along the ground.

Metal fastenings where babbitt is used should be warmed before pouring to prevent chilling. Care should be taken also not to have the babbitt overhot, as the life may thereby be burned out of the rope, and a serious defect and lack of strength caused. Clevises and clips should fit the rope perfectly. Sharp bends in wire rope are very dangerous and injurious. For this reason a cable should always be bent around a thimble when making a loop.

Sizes of Sheaves for Cables The durability of cables depends chiefly upon the diameter of the sheaves over which they run. Nothing will cause a wire rope to wear out more quickly than the rapidly changing stresses to which it is subjected in passing over fast-running pulleys of small diameter. The minimum diameters of sheaves that should be used with lifting- and counter-weight-cables composed of standard rope, nineteen wires to the strand, are stated in the following table:

Size of Cable	Minimum Diameter of Drum or Sheave
1/2 inch	27 inches
9/16 "	33 "
5/8 "	40 "
3/4 "	45 "
7/8 "	51 "
1 "	60 "

A single idler of too small diameter in a system of sheaves will soon ruin a rope. Thus it sometimes happens that the elevator-machine cannot be put directly underneath the shaft and in line with the pull. The deflection may be only 10 or 15 degrees, and an idler of 10 inches in diameter is put in. This is too small, one smaller than those indicated in the foregoing table should never be used.

Smaller pulleys may of course be used for hand-ropes composed of tiller-rope.

Fastening and Care of Sheaves All sheaves, drums, etc., should be fastened in place with proper keys. Set-screw fastenings should not be used. The bearings should be kept well lubricated. Care should be taken that nothing is adjacent to sheaves and drums that can fall into them and cause the cables to run off or to be jammed.

If a traveling- or auxiliary-sheave bushing becomes worn, so that the sheave binds, turn it half round and thus obtain a new bearing. If it has already been turned once, renew the bushing.

Sheaves, drums, etc., should be examined frequently for cracked spokes or other defects.

Traveling-sheave straps should be carefully examined periodically, to detect fractures. Whenever the slightest doubt exists of the safety of these straps, the traveling-sheave should be disconnected, so that a critical examination may be made.

All sheaves for operating-cables should be provided with proper guards to prevent the cable running off the sheave.

There is danger of having the arm caught while reaching in to the center sheaves of a horizontal machine, as the car may be started. To avoid this danger, the car should be run down to the bottom and the hand-valve in the supply-pipe closed before attending to the sheaves. If it is found impossible to get at some of the center sheaves when the car is at the bottom, it may have to be run up a short distance. In such case the car should not be run up farther than is absolutely necessary to give access to the sheaves, and the operator should be warned not to move the car, and the hand-valve in the supply-pipe should invariably be closed, before reaching in to the sheaves. If the hand-valve is so located that it cannot be seen by the man working at the sheaves, means should be provided to lock it in the closed position, so that meddlesome persons may not be able to open it and start the machine without his knowledge.

Lock-Nuts on Valve-Stems

The lower ends of the operating-valve stems of hydraulic elevators should always be provided with lock-nuts and split-pins. A split-pin should also be used at the connection of the valve-rack with the valve-stem. If this is not done, the parts may work loose and render the elevator uncontrollable, thus causing a serious accident.

Position of Elevator-Machine The machinery for operating elevators should be placed so that every part is easily accessible and good illumination may be obtained. Too often it is placed in some dark, inaccessible corner, where it is impossible and dangerous to give it proper attention and inspection.

Machines in factories should be placed in a separate chamber, or else fenced around to prevent any barrels or boxes being rolled up against them.

Care of Guides The guides should be cleaned off occasionally with a little kerosene oil. When they have been properly cleaned, they should be lubricated with a compound of seven-eighths cylinder oil and one-eighth graphite, well mixed. This should be done at least once a month.

Lubrication of Hydraulic Cylinders Use a purely animal oil or grease. A petroleum oil is a poor resistant of water, being carried away by it very quickly. Lubricate the inside of the cylinder every two weeks. Open the two circulating-cocks after the oil-cup is filled, and allow oil to run into cylinder. Leave cocks open about one-half hour. Do not neglect to close the cocks, otherwise the car will settle.

Automatic Stop-Motions Stop-buttons should be provided on all hand-ropes, starting-ropes, rods, or chains, to stop the elevator automatically at the highest and lowest points of its travel.

All drum machines, whether electric or belted, should, in addition, be provided with an automatic stop-motion, to prevent over-running at top and bottom, independently of the stops on the hand-rope. The mechanism usually consists of a revolving screw fitted with one or more traveling-nuts, so arranged that when the elevator reaches the top or bottom, the nuts engage a pinion mounted loose upon the shaft of the screw and cause it to revolve. The pinion, in turn, through suitable gearing or other means, moves the belt-forks, or in the case of an electric elevator, actuates a revolving switch, and the elevator is stopped.

All drum machines, whether electric or belted, should be provided with a slack-cable device, which automatically cuts off the power and applies the brake in case the elevator is obstructed in its descent from any cause and slacks the main lifting-cables.

The automatic stop-mechanism should be kept in perfect working order in all types of elevators.

Keep the stop-buttons on the hand-cable of a hydraulic elevator adjusted, so that the car will stop a few inches beyond the top landing and a few inches below the bottom landing, unless such adjustment of the stop-buttons permits the car to strike the bumpers, or the piston to strike either cylinder-head. When this adjustment permits the car to strike the bumpers, the bottom stop-button will have to be moved upwards, and when it permits the piston to strike either cylinder-head, one or both of the stop-buttons, as the case may be, must be moved. The maximum speed desired for the car may be fixed by fastening the back stop-buttons, so that the valve may be opened either way only enough to give this speed.

When a new hand-rope is put on, the position of the automatic stop-buttons should have especial attention for several weeks, and should be changed from time to time to compensate for the stretching of the rope. Accidents have occurred through failure to make the necessary adjustments.

Removal of Air in Cylinder If the car of a hydraulic elevator springs up and down when stopping, it usually signifies the presence of air in the cylinder. Often the opening of the air-cock and running a few trips will remove the air. If it does not, run the car to the top, place the valve for the car to descend, and then while in this position, open the air-cock and allow the air to escape. It may be necessary to repeat this operation several times.

Strapping of Counter-Weights It will sometimes happen that, through the accidental derangement of the machinery in one way or another, the counter-weights will be drawn up into, and will strike, the overhead work, thereby dislodging one or more of the weights and causing them to come crashing down upon the car. When insuring elevators, the counter-weights of which are held in place by U-shaped grooves at the ends fitting around through-bolts or rods, which is the common practice, or by other means than

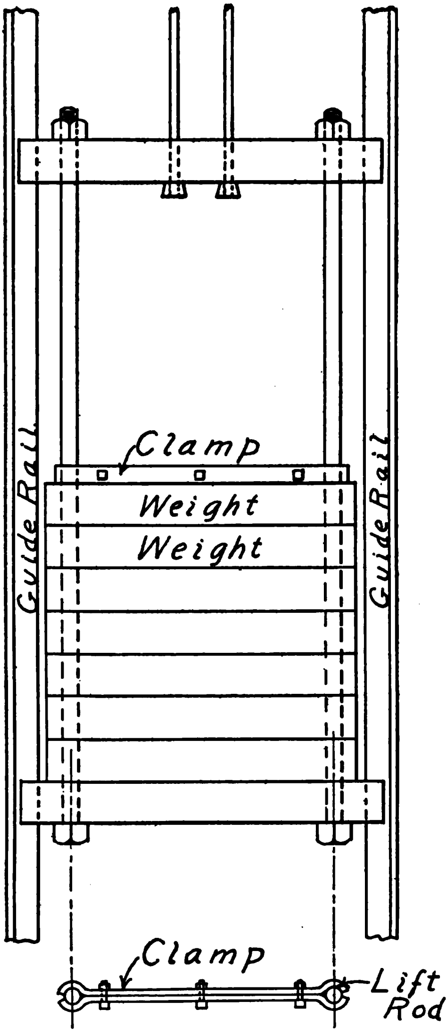


FIG. 20. ELEVATOR COUNTER-WEIGHT STRAPS

by bolts passing through holes cored in the weights, it is the practice of the Fidelity and Casualty Company to recommend that the weights be clamped. This is simply and efficiently done by clamping two iron straps above the weights and around the long through-bolts or rods. The straps should be about ½ inch by 2½ inches, and should be fastened together by three bolts as shown in Fig. 20. By this means the rods will be held together and the weights will be held in place, and the weights will not fall out by the rods spreading nor be jarred out, should the weights strike the overhead work. The straps may easily be removed and replaced when necessary. If the weights have too much play in the frame-rods, the rods should be drawn in toward each other before clamping. Both the car counter-weights and the drum counter-weights should be clamped with these straps.

The use of these straps is particularly important on electric and belt-machine elevators, as the danger of overwinding is greatest with these types. In the case of hydraulic elevators, the straps may not always be necessary, for if there is considerable clearance between the counter-weight and the overhead beams, the danger of the weight being pulled up against the beams is somewhat remote, as the piston will bottom in the cylinder first.

The latest and best practice is to use weights having two holes cored through them through which long bolts are passed, the only function of which is to bind the weights firmly together; or to have the lifting-rods pass through the weights, holes being cast in the weights for that purpose.

Further Guarding of Counter-Weights

On all passenger elevators, the counter-weights should be enclosed at the top and bottom of the shaft for a distance slightly exceeding their own length with a substantial grille screen or solid enclosure. This will decrease the chances of any weights falling over into the shaft.

Counter-weights running outside the elevator shaft should be fenced off, or otherwise guarded.

Where two counter-weights run in one slide, the hoisting-drum counter-weight should invariably be placed below the car counter-weight, except in the "Graves" type of elevator.* If the drum counter-weight is above the car counter-weight, it is clear that if its cables should give way, the combined weight of both the drum counter-weight and car counter-weight would be thrown against the weight of the car, and this would probably result in the car running up into the overhead beams or timbers at considerable speed, thereby causing a serious accident.

Examination of Piston-Rods Piston-rods of hydraulic elevators should be thoroughly examined for corrosion at least once in six years, and if the water is bad, once in three years, or even more frequently. The procedure in the case of a vertical cylinder, will usually be about as follows:

1. Run the car to the top of the shaft and secure it there.
2. Disconnect traveling-sheaves from piston-rods.
3. Remove top cylinder-head.
4. Hold piston-rods in place with chain block and tackle while bottom cylinder-head is removed.
5. Lower piston-rods and piston to convenient position and remove nuts from lower ends of piston-rods.
6. Draw out one rod at a time, so as not to disturb any of the counter-weights, and examine it carefully. Do not have both rods out of the piston at the same time, for there is danger of the counter-weights getting twisted in such case, and this will make it extremely troublesome to replace the rods.

If either of the rods is corroded to any considerable extent at any point, take no chances but replace both rods with new ones. A corroded rod, in addition to being a continual source of danger, will also tear out the packing.

See that the piston-rods (if two) draw alike. A groaning noise in the cylinder usually signifies that the rods are not drawing alike, although this may be caused by worn-out packing. But if the packing is worn out, the car will not stand stationary.

---

*This arrangement is not feasible with a "Graves" elevator, as it will interfere with the operation of the safety-device.

Examination of Pressure Tanks All pressure tanks used in the operation of hydraulic elevators and which have been in use five years, should be thoroughly inspected internally, so that, in the event of any weakness, it may be discovered and remedied before an accident occurs. This recommendation refers particularly to pressure tanks that are located in the basement. Basement tanks carry more pressure than tanks located on the roof or in an upper story of the building. The pressure due to gravity is utilized in the case of roof and upper-story tanks.

Pressure tanks often become so pitted as to be unsafe for further use except at a greatly reduced pressure. Badly corroded tanks have exploded, causing loss of life and property.

Equipment of Pressure Tanks Every pressure tank should be equipped with a safety-valve or relief-valve of sufficient area to discharge the pump delivery without dangerous increase of pressure. Under no circumstances should a stop-valve be permitted between the safety-valve and the tank it is intended to relieve. The stop-valve may be closed accidentally and make the safety-valve inoperative.

All tanks should be provided with gauge-glasses, man-holes, and other standard approved appliances.

Air Cushions Air cushions at the bottom of elevator shafts to receive the car in case it falls and to minimize the shock are required by the local ordinances in some cities and towns in the case of passenger elevators. While they no doubt provide an additional safeguard, they are not generally considered essential when the car is provided with an approved speed-governor safety-device.

Automatic Elevators The use of automatic elevators has been confined heretofore to private houses. Their use there has been considered unobjectionable in view of the relatively infrequent use of such elevators and the probability that the greatest care would be exercised to keep the elevators in good condition, since the owner's own life and the lives of members of his family are at stake. But of late, automatic elevators have been installed in a number of places for the use of the public. In our opinion such installations are inadvisable. The frequent use of the elevators will give rise to wear and derangement of the many parts in the necessarily complicated control-mechanism, so that they will get out of proper adjustment, and a serious accident may occur sooner or later. In our opinion no elevator should be used for passenger service unless it is in charge of an operator. This is the law in many places.

Lifting Capacity A careful determination of the lifting capacity of every elevator should be made. A sign, preferably of metal, on which has been printed plainly the maximum number of pounds that the elevator can carry safely, should then be posted in a conspicuous position in the car.

The load that should be put upon the cables is best determined probably by ascertaining the breaking strength of the cable from the manufacturer, and then limiting the maximum working load to one-sixth to one-seventh of this breaking strength, making due allowance also for any deterioration in the cables by reason of use. In some cases it will be necessary, as, for instance, where the speed of the cable is excessive, to limit the maximum working load to one-eighth to one-tenth of the breaking strength.

The strength of the frame and platform of the car should also be taken into consideration. No load should be put on the car that will produce a stress in the frame or platform in excess of the safe stress estimated for these, with an allowance of a liberal factor of safety.

In determining the maximum load that the elevator can carry safely, it should be borne in mind that the weight of the car itself must be included in the load that is sustained by the frame, and that the unbalanced weight of the car must be included in the load that is sustained by the lifting-cables.

Speed of Elevators It is the practice of The Fidelity and Casualty Company to recommend in the case of passenger elevators insured by it that the speed shall not in any case exceed four hundred (400) feet per minute and that the speed-governor safety-devices be set to operate at a speed not to exceed six hundred (600) feet per minute. And generally it is better not to run the car at a speed in excess of 350 feet per minute, setting the speed-governor at 500 feet.

When elevators are run at a speed of 600 to 700 feet per minute, the speed-governors are usually set to operate at a speed of 900 to 1,000 feet per minute. At so great a speed as this, the safety-devices are practically useless in preventing injury to the passengers in case of accident, as the shock of stopping when the safety-device operates will be excessive, or the car will strike the bottom before the speed at which the safety-device operates is attained.

It is doubtful whether any saving in time is secured by running an elevator at a speed in excess of four hundred (400) feet per minute. At high speeds considerable time is lost by the operators having to run their cars back to floors that have been passed, to take on or let off passengers, through failure to receive a signal in time or to act on it promptly.

At high speeds the wear is excessive, and frequent and expensive repairs are necessary. There is therefore a decided loss of economy in operating. Safety and saving in expenditure are both promoted by moderate speeds.

Care of Electric Elevators

A safety-fuse should always be placed at the head of the elevator-machine in addition to the safety-fuse which is usually placed on the feed-wire entering the building. When replacing a fuse, be sure that the main switch is open and be careful not to touch the other wire with a tool or otherwise, as such contact is dangerous. Under no circumstances put in a larger fuse than is required and never put in a piece of wire. Either will surely cause the burning out of the motor sooner or later.

Open the main-line switch before attempting to clean, oil, or adjust the machine.

See that the operating-device is in the central position before closing main-line switch.

Always open the main-line switch upon leaving the elevator for the night, or any other time when the elevator is to be left idle.

Keep the brake on while cleaning.

If the brake is to be removed, have the car at the top of the shaft, and secure the drum before loosening the brake-bands.

Adjust the brake-spring to suit the working load. Be sure that the nuts and cotter-pins are in place on the brake-bands.

The worm-gear casing should be filled sufficiently to cover the worm with special worm-gear oil or a mixture of about the following proportions: one gallon vegetable castor oil, one gallon cylinder oil, one quart machine oil. If these are not at hand, a good substitute is heavy cylinder oil, or better still, cylinder oil containing about one-half pound of flake graphite to the gallon. This oil should be filtered once a month. Add a little once a week to make up for leakage. Drain out all oil and thoroughly clean the housing and gears with benzine or coal oil every four months.

Inspect the worm and worm-wheel occasionally through the hand-holes in the casing to see that they are well lubricated and that no grit gets into the oil. They should show no serious wear.

Keep motor bearings supplied with best dynamo oil. Wash out bearings with benzine and renew with fresh oil once a month. Do not let any oil get on the fields or armature, as it will ruin the insulation. Keep the commutator free from grease and dirt by occasionally rubbing it with a cloth slightly moistened with oil. After cleaning, remove all oil with a dry cloth. Other electrical contacts should be cleaned like the commutator, and should be smoothed with emery-cloth or fine sand-paper in case they become rough.

Be sure the traveling-nut cuts off as it should.

None but one thoroughly familiar with the mechanism of an electric elevator should attempt to adjust the shipper-wheel, its connecting gears, brake, or controller-switches, on a hand-rope electric elevator. If any of these parts are incorrectly adjusted a very serious accident may result.

Elevator Operators Every passenger elevator should be in charge of an operator. It is the opinion of The Fidelity and Casualty Company that whenever possible, the operator should not be less than twenty-five (25) years of age.

In the case of freight elevators, it may not always be possible to have the elevator constantly in charge of an operator whose only duty is to run the elevator, although this should be the practice wherever the use of the elevator is frequent enough to warrant it. Where the use of the elevator is not frequent enough to warrant having an operator constantly in charge, it is advisable wherever practicable to designate one man to run the elevator in addition to his other regular duties, and never permit anyone else to run it. Where the conditions impose the necessity of permitting a number of men to run the elevator, the number of men having such permission should be as few as possible, and these men should be chosen for their carefulness and competency. The indiscriminate use of an elevator by a number of persons should be prohibited.

Rules for Elevator Operators By far the greater number of elevator accidents are due to the fault of the elevator operator. It is of the utmost importance therefore that the operator be properly instructed. The following rules are issued by The Fidelity and Casualty Company for the guidance of operators. Copies may be had on request:

RULES FOR ELEVATOR OPERATORS

1. Always start and stop your elevator gradually; a sudden start or stop may throw the cables off the sheaves and subject the entire machine to severe stress and danger of accident.
2. Never allow your elevator to be overloaded. When the car is comfortably full, request the remaining persons to ride on the next elevator, and close your door.
3. Always make sure that the passengers standing nearest the door, or opening of the car, are well within the car.
4. Never start an elevator until the door on the landing is closed and latched, and do not open the door on a landing until you have brought the elevator to a full stop.
5. If the hand-rope is too tight or too loose, *report it to the engineer*, who will adjust it properly. (The

tension of the ropes changes with the condition of the atmosphere.)

6. Be careful in running an elevator on the down motion. An increased load means increased speed, and the speed should be watched. Never try to show how fast the elevator can run on either up or down motion.

7. If you are running an elevator that is operated by a lever or wheel, never reverse the lever or wheel without care. Bring the car to a full stop, then move your lever or wheel in the direction you desire to go.

8. If for any reason the safety-device should operate and the car become pawled, don't touch the hand-rope or try any experiments, but *send for the engineer* in charge. Meanwhile keep cool, and keep your passengers from attempting to get out, as that is very dangerous.

9. Should your elevator for any cause refuse to go either up or down, bring the hand-rope, lever, or wheel to the center and leave it there. Don't try any experiments, but *send for the engineer.*

10. If you are running a belt elevator, be sure to pull the hand-rope or hand-chain as far as possible on either motion. By doing so you throw the belt full on the tight pulley, and thus prevent it from slipping. In stopping, use the check-rope.

11. If a belt elevator does not hold a load properly when it is stopped, *report it to the engineer* or person in charge. The brake requires adjusting, which is important.

12. If you are running a steam elevator, be sure to center the hand-rope or hand-chain when stopping the car, and if the elevator creeps after it is stopped, *report it at once.* The brake requires adjusting, which is important.

13. If you have a large amount of merchandise to take upstairs, it is safer to make two loads of it than to attempt to carry it all in one load.

14. If you are running an electric elevator, always center your hand-rope, lever, or wheel, when stopping, for if you fail to do so you are liable to burn out parts of the starting-box and motor. Electric elevators should never be overloaded, for the moment the load exceeds the lifting capacity, the fuse burns out and the elevator cannot be operated until a new fuse has been put in.

Never use a piece of wire as a substitute for a safety-fuse, for in such case you are bound to burn out the entire machine sooner or later.

15. If there is anything about the elevator that does not appear to be just right, or if you hear any unusual noise in or about the machine, *report it at once to the engineer* or person in charge. If the engineer cannot determine what the difficulty is, he should telephone or send at once to the office of The Fidelity and Casualty Company for an expert. Meanwhile no experiments should be tried.

16. Remember that nine accidents out of ten result from carelessness, and that human life may be lost if you are careless.

Additional Elevator Rules

If a hydraulic elevator creeps at all, investigate packing of both piston and valve immediately. In the case of all open-ended cylinders, leaking can be stopped up to a certain point by tightening up the piston-follower, unless the packing is worn out, while in the case of closed cylinders it is of course necessary to repack the piston or operating-valve, or both.

In the case of steam elevators, whether the pistons and valves of the engines are leaking seriously can best be determined by running the car to the top of the shaft and starting it down while empty. If the car gains speed in descending, it is pretty certain that the piston, piston-valves, or reversing-valves, or all of them, are leaking. In such event they should be promptly overhauled and put in proper condition.

Elevator wells or pits should be kept clean and dry. Never store any articles in them or run any electric wires across them.

Examine the safety-appliances frequently, placing a timber strut beneath the car to support it whenever getting in under it. Also inspect any sheaves in the pit. Do not attempt to do this or to oil the sheaves while the car is running, and in any case always notify the operator.

Inspect the belt on belted steam machines carefully at regular intervals for cracks or other defects. This should also be done in the case of belts on belt-machine elevators.

Rubber mats or some form of safety tread should be placed on the floor of all passenger cars. These should be replaced by new ones before they become so worn as to have holes in them. A person may trip by catching his foot in a hole.

Hand-trucks or other articles liable to shift should always be blocked while on the elevator platform.

Always look carefully to see that the car is at the landing, and that it has come to a full stop, before getting on or off.

Never permit any playing or skylarking about the elevator shaft.

Examine cables frequently for broken wires.

Try the governor occasionally to see that it works properly.

Reaching over the gate at any floor to the starting-ropes should be forbidden—it has led to many serious accidents.

Never depend on or use limit-stops in regular operation to stop the car at the top and the bottom. Limit-stops should be frequently inspected and carefully tested.

Useful Signs The following signs should be printed in large heavy type and placed in all freight elevators or on the gates, as is appropriate in the case of the given sign:

"This elevator is *for freight only.* All persons riding upon it do so at their own risk."

"Lifting Capacity......................lbs."

"Keep your hands and feet inside the car."

"Keep this gate shut."

"Do not lean on or look over this gate."

The Factory

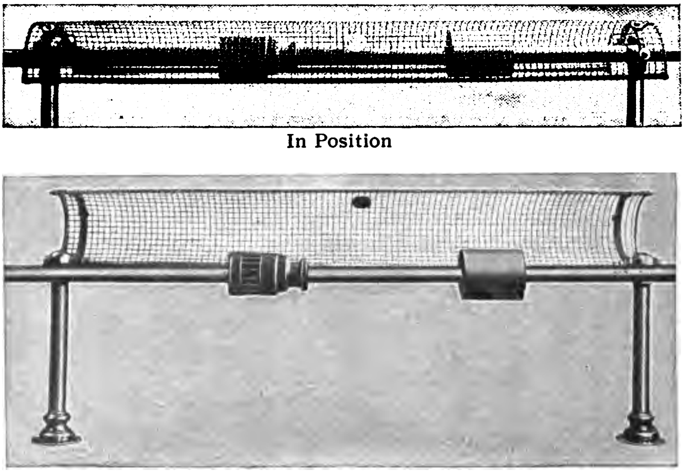
Cleaning Machinery Machinery should never be cleaned while in motion if it can possibly be avoided. The soft materials used in cleaning, such as waste and the like, catch easily in the gears, or other moving parts, and the workmen's fingers, hands, or arms are drawn in and broken and crushed.

Out of 1,866 accidents in the State of Massachusetts in the year 1907 (fatal accidents not included) which occurred in the operation of machinery, 826, or over 44 per cent., were to "persons who met their injuries while attempting to clean the machinery when it was in motion, in trying to remove waste, bobbins, or some other article which had become caught in the machine, in oiling the bearings, or in some other way incurring risks which carefulness and prudence would have avoided" ("Massachussetts District Police Report" for 1907, page 109).

It is particularly important that minors under sixteen years of age shall not be required to clean shafting or other machinery while it is in motion. A young person will be much less likely to realize the danger than an adult, and will fail to exercise the caution that is necessary.

Guarding of Machinery All shafting and pulleys less than seven (7) feet above the floor should be securely fenced. Housings of sheet-metal, iron grille-work, wire netting, or wood, or railings of pipe or wood, may be used for this purpose. If it is impracticable to fence certain pulleys, their arms should be covered with a disk of sheet-metal or wood fastened thereto with screws or wire. The use of inverted U- or V-shaped sheet-metal shields, extending for a length of fifteen (15) inches on each side of shaft bearings requiring attention when the shafting is in motion, is recommended. Even perfectly smooth shafting is highly dangerous when in motion, and no one should ever be allowed to come into contact with it when it is in motion.

Shafting beneath sewing-machine tables and the like should be thoroughly covered with boards, sheet-metal, or wire netting. Fig. 21, reproduced from the Proceedings of "The Institution of Mechanical Engineers," of Great Britain, illustrates a guard protecting a horizontal shaft and coupling (it would be better still to have the guard more completely surround the shaft when under sewing-machine tables, etc.). It is supported on pipe-standards and hinged to permit of turning up for oiling as shown in the lower cut. All other shafting operating on or near the floor should be at least completely fenced.


In Position

Open for Oiling

FIG. 21. GUARD OVER SHAFT AND COUPLING

Vertical shafts passing through floors or rising therefrom should be securely fenced to a height of 5 or 6 feet. This is well done by simple boxing with one side hinged to permit of easy inspection.

Projecting shaft-ends, when not otherwise guarded, should be covered with a sheet-metal cap.

Painting Moving Parts of Machinery Red All *moving* painted parts of machinery, and other *moving* parts wherever practicable, should be painted *bright red.* Although this method of warning has thus far been confined in this country almost entirely to high-tension electrical apparatus, it has been extensively applied to machinery in general in European countries, and has proved a most efficient aid in the prevention of accidents.

Oiling Shafting The oiling of shafting should be done whenever possible while the machinery is at rest. Better still, the bearings may be fitted with automatic lubricators which need be refilled only when the shafting is not in motion. But sometimes the shafting requires attention while in motion, and safe means of access should be provided for this purpose. The following means are the safest:

1st. A service platform suspended by metal straps from the ceiling, or carried on brackets attached to a wall or to columns. Such a platform should be provided with a hand-rail three feet high and a skirting-board about six inches in depth, the latter to stop the foot in case of slipping.

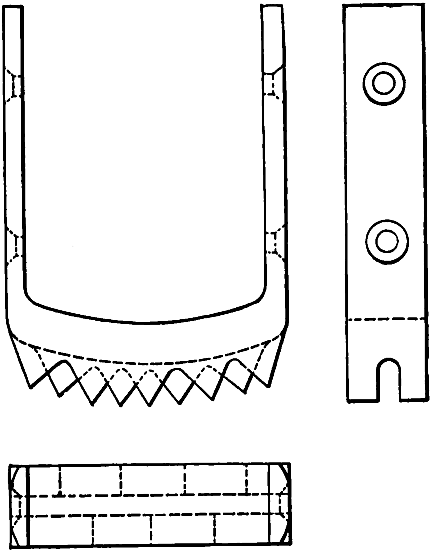


FIG. 22. LADDER FOOT SAFETY-DEVICE

2nd. A ladder provided with hooks or hangers to fit over the shaft at the upper end, and with some material to prevent slipping at the lower end (a ladder should never be permitted to lean against shafting in motion if it is possible to avoid so doing). For wood or cement floors iron straps pointed at the end and screwed to the sides of the ladder, so as to project some two inches below the bottom, are considered best. Fig. 22, which appeared in the "American Machinist" for August 27th, 1908, presents an elaboration of this device which has been very successful. These "feet" are made of malleable iron and are fastened to the ladder with ordinary wood-screws. The "foot" illustrated in the sketch is for a ladder 3 inches wide at the foot and has 10 staggered teeth on the bottom at about ¾ inch centers.

Rubber is also used to some extent for this purpose, but is liable to slip on a wet or greasy floor.

In no case where a line of shafting is close to a wall should an attendant be allowed to fix a ladder against the wall, and thus place himself between the shafting and the wall. Working in a cramped space like this, close to a rapidly revolving shaft, is dangerous.

3rd. The use of a car hung from a rail or I-beam along the shafting, the rail or beam being suspended from the ceiling.

The oil-cans used in oiling shafting and heavy machinery should have necks at least nine (9) inches long.

Whenever the shafting or machinery thus requires oiling or other attention while in motion, the work should be done preferably by one man, who should be required to wear exceptionally tight-fitting clothing to lessen the chances of his being caught in the machinery.

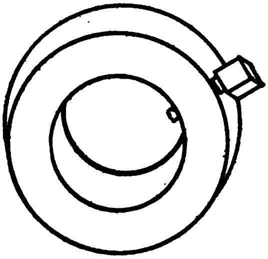


FIG. 23. PROJECTING SET-SCREW

Projecting Set-Screws

Projecting set-screws when on line-shafting and revolving parts of machines are a constant menace to life and limb. The ordinary clothes-catching set-screw in a collar is shown in Fig. 23.

This hazard may be overcome at a trifling cost in any of the following ways:

1st. By countersinking, as in Fig. 24. The set-screw may be adjusted by the box-key shown therewith. Of course this method requires either a shorter screw or a thicker collar.

2nd. By using a flat-head set-screw slotted to take a screw-driver, as in Fig. 25.

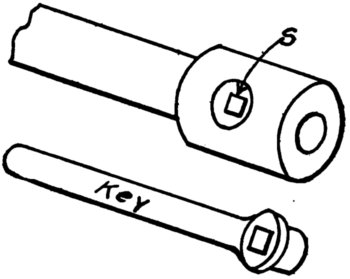


FIG. 24. COUNTERSUNK SET-SCREW

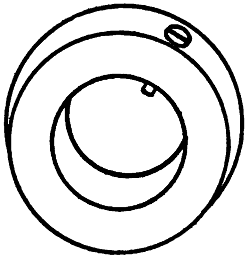


FIG. 25. SLOTTED-HEAD SET-SCREW

3rd. By the use of hollow set-screws.* These are made to take a hexagonal key or socket-wrench, as shown in Fig. 26.

Either of the latter two obviate the necessity of countersinking, and may be used instead of the old square-head screws. As it does not matter whether they come flush with the surface of the collar or pulley-hub or set below it, only one length of each size of screw is required for any depth of hole. These screws may be protected against rust by filling the hole above the screw with wax. If the hole is quite deep and it is desired to lock the screws, one screw may be put down on top of the other. The hollow type is to be preferred to the slotted-head screw because there is not the danger of twisting the head off as in the case of the latter.

In a case where for any reason it is imperative that the old square-head set-screws be retained, it is strongly recommended that one of the following guards be applied:

---

* Patented

1st. A sheet-metal plate curved to fit snugly over the screw and to spring on around the shaft. This serves both to keep the head from catching in clothing, and incidentally to retain the screw should it loosen.

2nd. A piece of leather-belting laced about the screw. This is the method used to guard projecting set-screws at the plant of the Lidgerwood Manufacturing Company, New York.

3rd. Wooden guard-rings. These are made in halves with a recess bored for the screw-head to fit in, and screw together, thus forming a perfectly smooth ring which may be easily removed and replaced.

4th. When set-screws or keys project at the end of a shaft they may be covered by a sheet-metal cap fitting over the shaft.

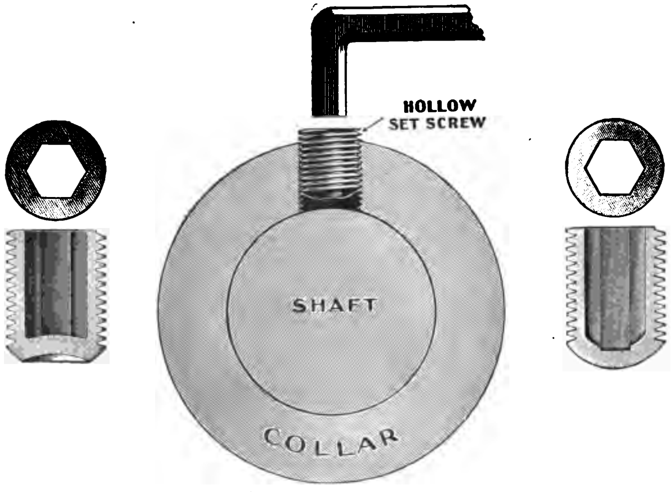


FIG. 26. HOLLOW SET-SCREWS

Shaft-Couplings Fig. 27 shows the ordinary flange shaft-coupling with its array of clothes-catching bolt-heads and nuts. These are a menace equally with projecting set-screws. Figs. 28 and 29 illustrate two forms of safety-coupling. In the former there is used the thickened-flange coupling and recessed bolt-heads and nuts, and in the latter the rim-flange coupling beyond which the bolt-heads and nuts do not project. In either case it is next to impossible for them to catch in the clothing. The safety feature should never be lost sight of when purchasing a coupling.

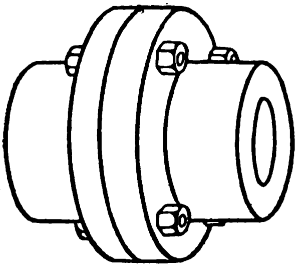


FIG. 27. PROJECTING-BOLT COUPLING

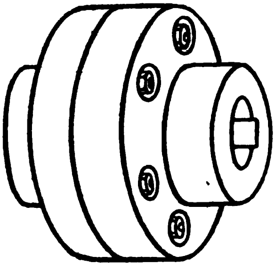


FIG. 28. THICKENED-FLANGE SAFETY-COUPLING

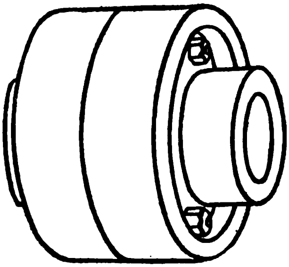


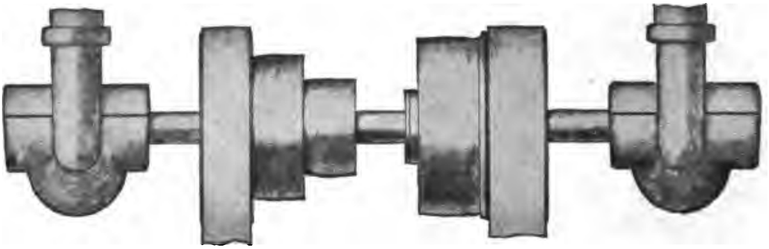
FIG. 29. RIM-FLANGE SAFETY-COUPLING

(See note on page 167)

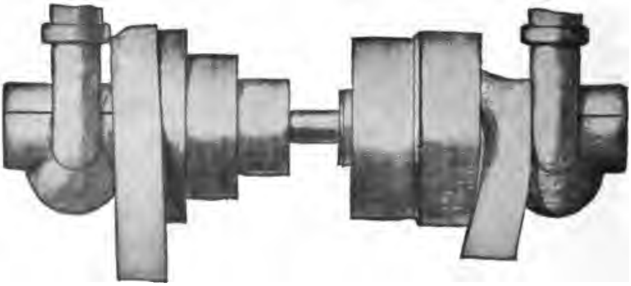
Guarding Belts Main belts which run through the floor should be boxed or fenced in to a distance of six (6) feet above the floor.

Small belts if running close to or through the floor should be guarded sufficiently to prevent contact with a workman's clothing. If a man gets caught, cut a belt if this is quicker than stopping the machinery. Where belt connections are made with motors or exhausters, the belts run usually at very high speed and it is well to fence off the whole apparatus.

Pulleys should not be nearer a shaft-hanger or other obstruction than the width of the belt. This precaution will prevent the belt becoming wedged if it slips off the pulley, with the attendant danger of pulling the shaft down on to a workman. Fig. 30, reproduced by courtesy of the Brown & Sharpe Manufacturing Company, of Providence, R. I., shows the right and wrong way to space pulleys on counter-shafts. The upper cut shows the right way; spaces are allowed so that if the belts slip off they cannot wedge and pull the counter-shaft down on to a workman. The lower cut shows the wrong way, insufficient space being left for the belts should they slip off. This will endanger a workman as the counter-shaft may be pulled down on to him.



THE RIGHT WAY
COUNTER-SHAFT WITH SPACES ALLOWED SO IF BELTS SLIP OFF THEY CANNOT WEDGE AND PULL THE COUNTER-SHAFT DOWN ON TO THE WORKMAN



THE WRONG WAY
COUNTER-SHAFT SHOWING HOW BELTS MAY WEDGE WHEN THEY SLIP OFF THE PULLEYS IF THE SPACE ALLOWED IS TOO NARROW. THIS WILL ENDANGER THE WORKMAN AS THE COUNTER-SHAFT MAY BE PULLED DOWN ON TO HIM

FIG. 30. SPACING OF PULLEYS ON COUNTER-SHAFT

A belt should not be allowed to rest on a moving shaft. Something may catch and cause it to be wound around the shaft.

In every place where it is desired at times to unship a belt, a belt-perch or hook on which to rest the belt should be provided, so as to prevent the belt from coming into contact with the revolving shaft.

In cases where a pulley is situated very near a journal, a guide-bar should be placed close to the pulley, on the side opposite to a belt-perch or hook, at the point where the belt runs on to the pulley. This will prevent the belt falling between the bearing and the pulley, and causing damage.

Belt-Lacings The tearing and flying-off of high-speed belts is largely due to improper lacing. The lacing should be smooth and flat in order that the shock caused in passing over the pulleys shall be the least possible. It will be readily recognized that if an excessive shock is caused in passing over the pulleys, the parts of the belt adjacent to the lacing will be subjected to heavy stresses, which will in time tear the belt. When this occurs, the belt is liable to fly off and cause serious injury to anyone standing by.

Belt-lacings should be tucked well and the excess length cut off close to the belt so that it cannot catch in anything. Should a lacing catch, it may result in the unshipping of the belt.

Belt-cords on automatic machinery running at high speeds should be sufficiently guarded to prevent flying in case the cord breaks.

Shipping Belts In replacing a belt upon its pulley on a shaft in motion, a pole or other similar means should be used wherever possible.

Figs. 31, 32, and 33, which are reproduced from the February 18th, 1909, issue of the "American Machinist," show a good form of belt-pole in three different positions. No especial description is necessary, as the cuts show its construction and method of use. It is most important that the length of such a pole shall be nearly equal to the distance of the shafting from the floor, thus forcing the workman to hold it at his side instead of in front of him. A short belt-pole is in itself a source of danger, owing to its liability to deal a severe blow in case of the pole becoming entangled in any way; fatal accidents have occurred in this way.

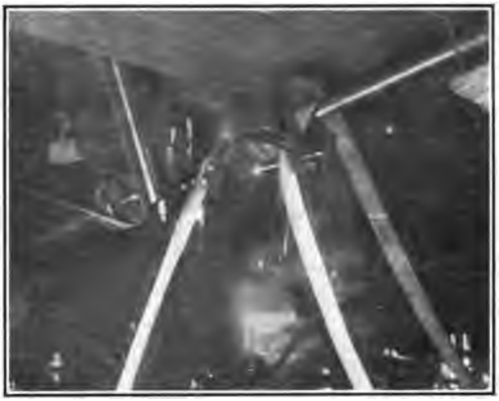
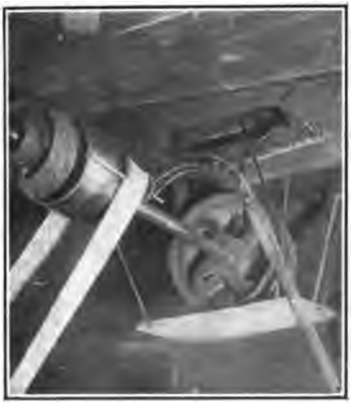


FIG. 31. BELT-POLE—Position 1



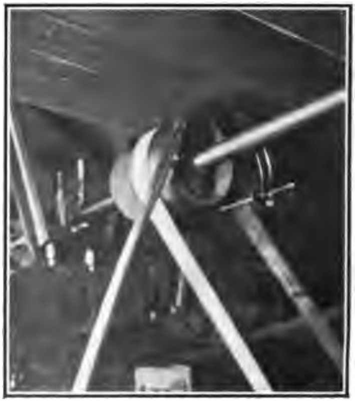


FIG. 32. BELT-POLE—Position 2

FIG. 33. BELT-POLE—Position 3

Often a belt is too large to be handled by a belt-pole, and it becomes necessary for a workman to use a ladder in replacing it. In this case, the ladder should be placed on the side of the pulley opposite the belt, as this position facilitates the operation, and lessens the danger of the workman becoming caught and being drawn over the shaft. This is a dangerous operation at best, and should be avoided wherever possible, especially on high-speed shafts.

In unshipping belts, a belt should always be thrown off the driving and not off the driven pulley.

Belt-Shifters Loose pulleys and belt-shifters, or clutches, should be used wherever possible for throwing machines out of motion when not in use. No employee should be allowed to shift a belt with his hands or a stick while the machinery is in motion. The practice of shifting belts by hand is dangerous, even though they travel comparatively slowly. In cases where belt-shifters are not provided, or where it is necessary to shift or repair belts on single pulleys while the machinery is in motion, these operations should be performed by one man detailed for all such work, who should be provided with suitable appliances for the purpose.

Care should be taken to make the belt-shifter action used for removing a belt to the loose pulley, of a positive character, either by employing one of the many forms of locking-gear or a balance-weight. Many accidents have arisen through the lack of this precaution, the belt creeping back on to the tight pulley, and the machine thus starting unexpectedly. This applies particularly to wood-working and other high-speed machinery.

Machinery of this class is also set in motion without warning, sometimes, by the loose pulley seizing upon the shaft or by the side friction of the adjacent rims of the pulleys. This danger may be avoided by the mounting of the loose pulley on a well lubricated idle stud, co-axial with the machine-spindle, and using a collar which prevents any end motion in the direction of the tight pulley. The same object may be attained with existing troublesome loose pulleys by encasing the necessary bearing length of the shaft in a collared sleeve which does not revolve with it and on which the loose pulley runs.

Guarding of Gearing All gearing, sprockets, and chains with which a workman may come into contact, should be completely covered, so as to leave no point of danger between the guard and the gearing. Small and moderate-sized gears may usually be well guarded by a strip of sheet-metal screwed on to some adjacent stationary part and bent to conform to the contour of the gears. Very large gears may often be fenced to advantage. A train of small gears is best guarded by a wooden or metal casing, so constructed that it may be easily removed for repairs or oiling.

Pulleys Frequent inspections of the numerous small pulleys in use in every plant should be made. The arms of cast-iron pulleys are very liable to crack. When this occurs, a piece of the rim may be thrown out by centrifugal force and may cause serious, if not fatal, injury to any workman nearby. The wheels should be hammer-tested frequently, to detect cracks.

Cranes, Winches, Etc. These should be carefully inspected at frequent intervals for such dangerous defects as worn chains, ropes, sheaves or pins, broken split-pins, etc. All platforms should be provided with skirting-boards to prevent the accidental rolling off of spanners or necessary tools in use.

All winches should be provided with efficient brakes. The crank-handle of a hand-winch should not be permitted to attain a high velocity in running down. Fatalities have occurred from the handle flying off, due to centrifugal force.

The following matter regarding cranes is taken from an article in the August 12th, 1909, issue of the "Electrical World":

"All overhead cranes should be provided with a railed walk the entire length of the bridge. It seems strange that manufacturers would build cranes without these walks, but they do. These cranes should also be equipped with foot-gongs for the use of the operator, with a box on the bridge in which to keep tools and oil-cans, and with limit-switches to prevent running the hoist-blocks into the drums and probably breaking the cables, allowing the burden to fall on to workmen below.

"Each crane should have a switch installed at some point on the bridge which will cut off all power, making it impossible to start the crane from the cab. Many men have been injured while working on the top of a crane by a thoughtless craneman forgetting for the moment that they are there and starting the machinery.

"Each man working on a crane should be provided with a warning sign bearing his name, which he should attach to the safety-switch, warning all not to throw in that switch as he is working on the machinery.

"All overhead cranes should be equipped with sweep-brushes extending out from the truck-wheels, sweeping the rails, the purpose being to warn a person resting his hand on the rail of the approach of the crane. The number of arms and hands lost by persons working on scaffolds along crane-runways, who thoughtlessly rest against the runway and fail to notice the approach of the crane, is appalling. Four instances have come to my personal knowledge within the past year where these brushes have prevented such accidents.

"No man should ever be allowed to go on to an overhead crane runway without permission from his foreman, and then not until the cranemen have been notified and steps taken to protect him from the cranes while he is on the runway."

Chains Hoisting and other chains under heavy stress from time to time, grow weaker continuously by reason of the crystallizing of the metal. The action of crystallization will continue to a point where rupture will occur under a comparatively light load, unless checked by annealing the entire chain at least once every six months. The effects seem to be more marked in metal which undergoes the interchange of heat and cold very often, and to these especially should such treatment be applied. Chains should be carefully examined for any weakness, at regular intervals.

Guarding of Hoists Hoists are of two kinds, namely,—those inside and those outside the factory. A common form of inside hoist, especially in grain mills and warehouses, breweries, etc., has a square opening in the floor at each level, which is closed by two hinged trap-doors. These doors open as the bag or bale, etc., passes up through them, but not attaining a vertical position, fall back into place immediately the bag or other load has cleared them. The chain-holes in the trap-doors should be bushed with metal, otherwise, owing to the rapid wear of the wood, the size of the hole may increase to dangerous proportions. In this class of hoist it is well to have a small stop on the trap-door hinges that will prevent the doors from being folded back upon the floors, leaving a dangerous opening through which a person may fall. Where the doors are ever left open for any length of time, a pair of hooked bars, one bar at each end, should be placed in position, as shown in Fig. 34, to act as a guard in conjunction with the open doors. Failing such contrivances, posts should be fixed at each corner of the opening, supporting stout rails on three sides of the opening. The fourth side is best guarded by a hinged bar or a hooked chain. Where only bags or similar loads are handled, the fourth side may be railed also, and shelves provided at one or more sides on which the bags may be deposited and unslung.

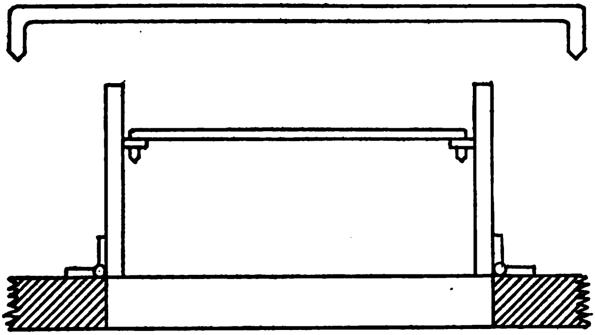


FIG. 34. HOOKED GUARD-BARS FOR HOISTS

In the case of outside hoists, it is good practice to erect a substantial landing or platform outside the building on a level with each floor. Each landing is provided with a couple of flaps or trap-doors which open as soon as the load comes into contact with them and close automatically when the load has passed above the platform, as already described in the discussion of inside hoists. All outside-hoist doorways should be provided with doors or with secure bars or chains, and at each side of the doorway efficient hand-bars should be put up, which a man may grasp when looking down from the doorway or reaching out for a load.

Position of Machinery Under no circumstances should machinery be crowded, so that those using passages are placed in danger.

Any passage toward which a planer-platen, lithographic printing-table, self-acting mule, or other carriage, runs, should have eighteen (18) inches space in the clear between the carriage and any fixed structure, when the carriage is fully out.

Occasionally a shaft or belt running across or projecting into a stairway is met with. Such shaft or belt should invariably be boxed in, and a warning sign hung from the guard-box if it encroaches on the headroom.

Guarding Fans and Blowers Revolving fans and the intakes of blowers within reach of persons standing on the floor, or on adjacent platforms, should be guarded by wire screens of not greater than one-half inch mesh.

Emery Wheels and Grindstones Emery wheels and fast-running grindstones should be enclosed by a substantial guard, fastened to the wheel-base and of sufficient size and strength to withstand the shock of the flying parts of a bursting wheel. The fact should be recognized, of course, that an emery wheel may be broken or caused to burst from improper use, as, for instance, excessive pressure or blows when grinding a tool, as well as from excessive speed.

Fig. 35 shows what is considered to be the best guard of this kind. The wheel is entirely surrounded except for a small open space at the front of the wheel above the rest. There is ample space to work conveniently, and yet the wheel is well guarded and the workman protected.

Another good safety-device is so designed that the wheel plays a part. The sides, instead of being parallel, are divergent, so that the thickest part of the wheel is at the center. A number of sets of steel safety-collars are furnished, varying in size so as to allow for wear of the wheel, which fit the wheel tightly to a distance of two inches from the grinding surface. In case the wheel ruptures, the tapered sides cramp between the collars and so do not allow the pieces to fly. A number of manufacturers of emery wheels loan safety-collars free of charge to the users of their wheels. Advantage should always be taken of this offer.

The following suggestions as to the use of emery wheels should be carefully observed:

Do not have the rest so far away from the wheel

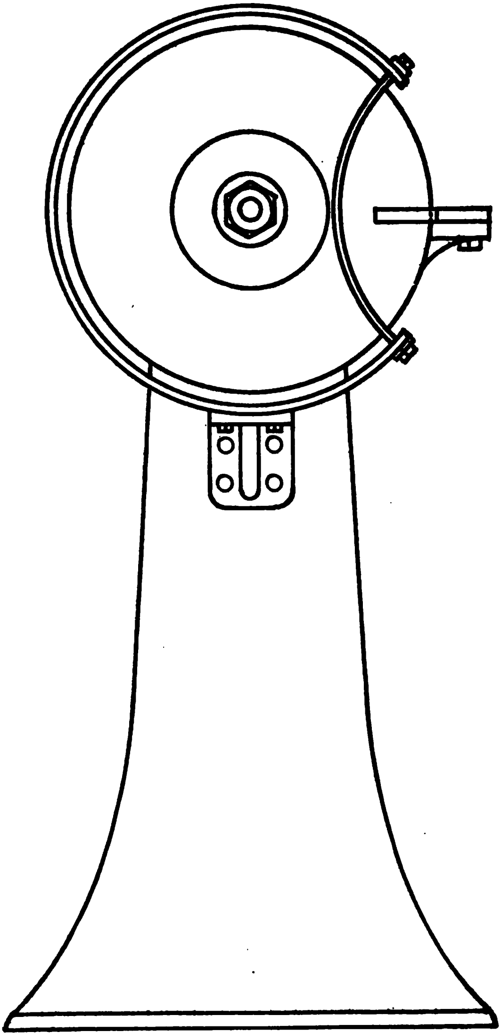


FIG. 35. EMERY-WHEEL GUARD

that the work may become cramped. The use of a releasing-rest may be the means of saving crushed fingers. This applies also to grindstones.

Keep the boxes well oiled so that the arbor will not become heated, and by causing expansion rupture the wheel.

Never crowd an emery wheel upon an arbor. Have the wheels slip easily on the mandrel, and screw them only tight enough to prevent slipping. Wheels should be mounted so as to run true and steady.

Do not allow the wheel to vibrate when running at normal speed. If there is vibration, either true up the wheel or re-babbitt the boxes after truing up the journals, or both.

Never mount wheels without flanges.

Do not use too small or too light flanges, and have them properly concaved. They should be at least one-third the diameter of the wheel,—the makers in general recommend one-half as still better practice,—always concave, never straight or convex.

Never screw a nut directly against the emery wheel. It will "creep," and rupture the wheel from excessive side pressure at the bushing.

Never run a wheel above its indicated speed.

A workman on an emery wheel should keep his eyes and body out of the plane of rotation of the wheel; chips from the wheel will be less likely to strike him if this suggestion is heeded. The grinder will find that large glasses made of plain glass, or indeed his own spectacles, should he wear them, will afford great protection from flying particles. Or he may use other protectors made with glass in front and gauze surrounding the glass.

Great care should be taken in storing emery wheels and grindstones to keep them free from dampness. They should not be stored with the stone standing upon the ground, as it will absorb moisture. Likewise, the idle mounted stone used in wet grinding should not be left over night, or for any long period, with a portion immersed in water.

Particular attention should be paid to the guarding of grindstone belts and pulleys. Although these usually run at comparatively low speed, they offer much opportunity for injury to a man stooping to pick up a tool he has dropped (quite a common occurrence) in the process

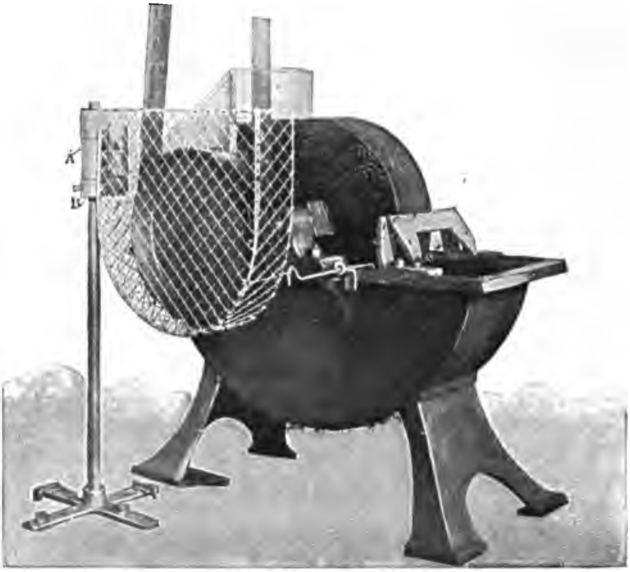


FIG. 36. GRINDSTONE-BELT FIXED GUARD—Closed

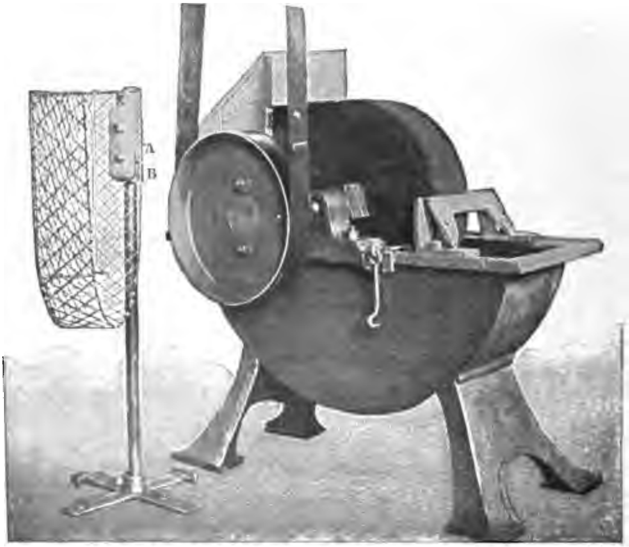


FIG. 37. GRINDSTONE-BELT FIXED GUARD—Open

of grinding. Figs. 36 and 37 (reproduced from the Proceedings of "The Institution of Mechanical Engineers" of Great Britain), show an excellent form of guard of stout wire for this purpose. The guard is fixed to the collar A, which moves freely about the pipe-standard. The lower face of this collar is furnished with a V-shaped projection which engages with either of the V-shaped slots in the upper face of the collar B, according as the guard is open or shut. The collar B is firmly fixed to the standard with a set-screw.

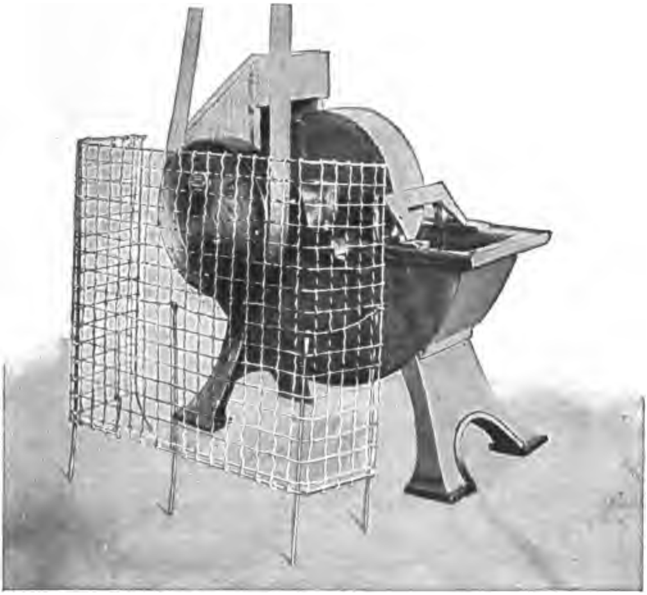


FIG. 38. GRINDSTONE-BELT MOVABLE GUARD

The objection to a movable guard for this purpose, of the type shown in Fig. 38, is that the man may have to remove the guard, and will thereby run the risk of being hurt by the unfenced belt or pulley when he stoops to pick up a fallen tool. Another objection to a guard of this kind is that a careless workman may remove it and fail to replace it.

Roll-Feed Machinery

All roll-feed machines should be well guarded by placing two strips of metal, where the thickness of the work will permit, the entire

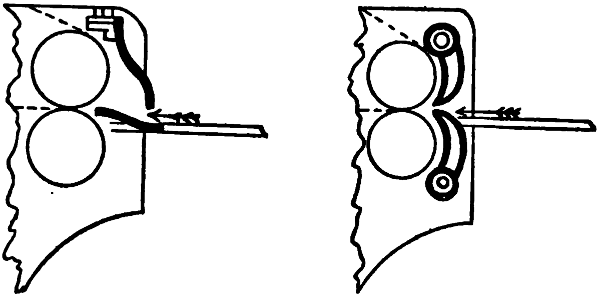


FIG. 39. GUARDS FOR ROLL-FEED MACHINERY
(See note on page 167)

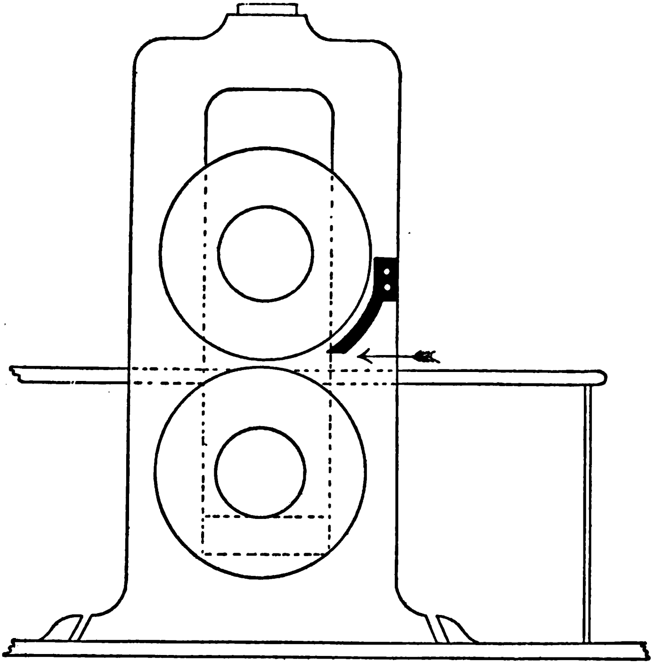


FIG. 40. GUARD FOR ROLL-FEED MACHINERY
(See note on page 167)

length of the rolls, so as to prevent the operator getting fingers caught in the rolls while feeding. Fig. 39 shows two good methods of placing such strips. If it is not practicable to use two strips, one placed as in Fig. 40 will often afford a large degree of protection. The strip should be placed near enough to the table to prevent the fingers coming into contact with the rolls.

Fig. 41, reproduced through the courtesy of the "Museum of Safety and Sanitation" of New York, shows a modification of this guard, a metal gate or grating being used. The foot-lever attached thereto permits the guard to be easily raised if necessary.

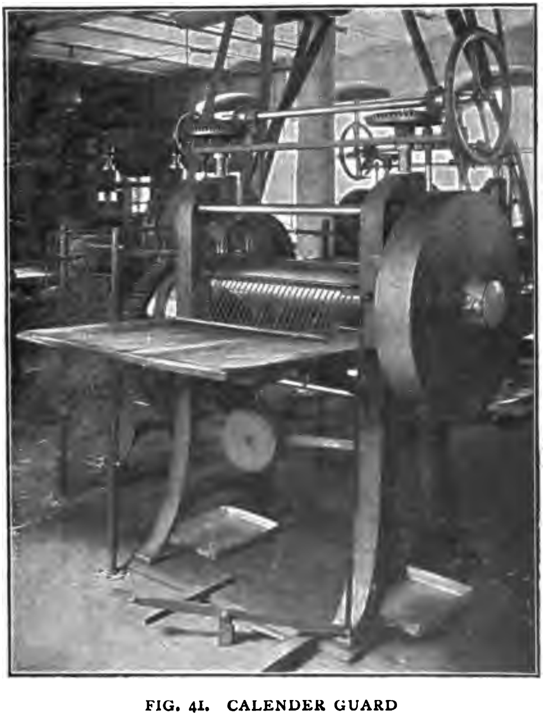


FIG. 41. CALENDER GUARD

The guarding of roll-feeds should receive special attention in laundries, candy factories, and bakeshops.

Paper-Box Machinery One of the most common injuries in paper-box factories is the loss or maiming of fingers in corner-staying machines.

Fig. 42, reproduced from an article in the July 1st, 1909, number of the "American Machinist" shows a guard for a corner-staying machine. This, the author says, has been used for several years and has proved very effective. We quote from the article as follows:

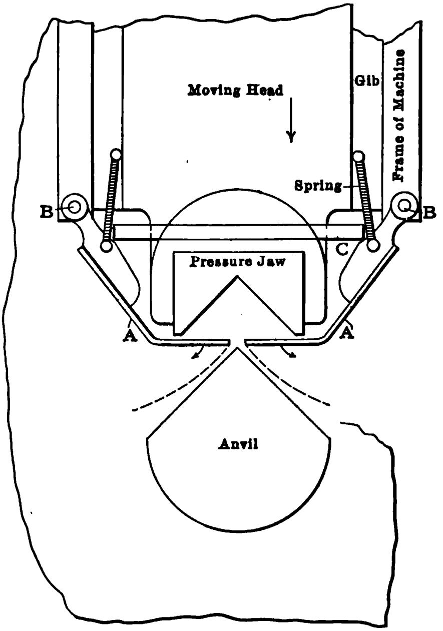
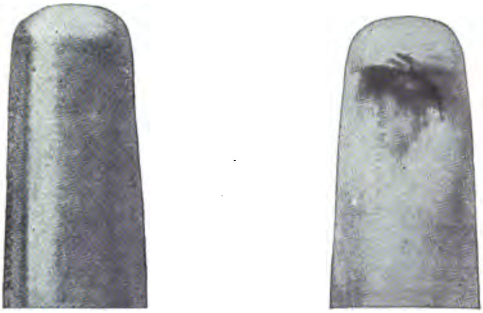


FIG. 42. GUARD FOR CORNER-STAYING MACHINE

"On this machine the box corners are completed or reinforced; the operator places on the anvil (or solid support) the two sides which form the corner. These must be held in position while the machine feeds forward a strip of cloth or paper with a moist surface, cuts it off at the right length, and with a powerful squeeze forces it firmly along the sides, thus forming the substantial corner of a modern box.

"The machine will stop automatically at the end of each stroke if desired, or will run continuously, in which case the operator must whirl the box rapidly and accurately from corner to corner during the up stroke. As the normal speed is 90 complete strokes per minute, it is evident that the operator can give little thought to keeping his fingers safe, but with this device accidents are practically unknown. The sheet-metal guards A, hinged at B (see the cut), just clear the anvil as they swing down and out. A pin, C, in the moving head, actuates these guards in advance of the descending pressure-jaw, and any fingers in the danger zone will be forced to a safe position; the guard returns to position as the head moves up. This device allows the operator full use of both hands at all times."

Fig. 43 shows an inexpensive little device* for finger protection now on the market. These "finger protectors" are made of drawn steel, extra thick at the end. The cut shows a finger protector before and after an accident. It was worn by an operator of a corner-staying machine and was the means of preventing a badly crushed finger.



Before the Accident After the Accident

FIG. 43. FINGER PROTECTORS

Fig. 44 shows how the protectors are used, and Fig. 45 the result, should the protector on the operator's finger get caught, the finger slipping out undamaged. The use of the protectors will be found to interfere very little with the work. It is well to wear a glove-finger inside them to prevent rusting of the metal.

---

* Patented

These protectors have also been adopted with much success in other lines of work where the fingers are likely to be cut or crushed.

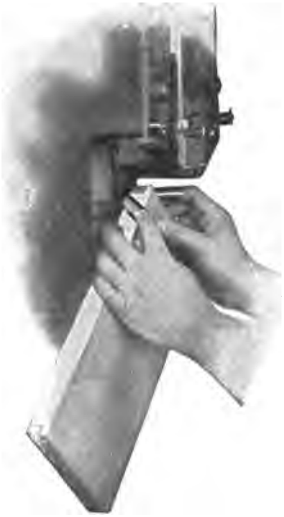


FIG. 44. FINGER PROTECTORS

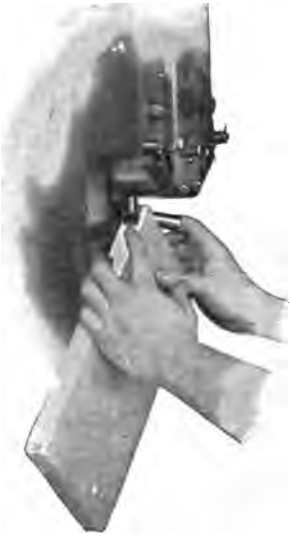


FIG. 45. FINGER PROTECTORS

Centrifugal-Dryers or Hydro-Extractors Under no circumstances should a workman attempt to place anything in, or remove any of the contents of, one of these machines while it is in motion. An arm may be twisted off in so doing.

Rubber mats, burlap, or other suitable materials, should be placed in front of every dryer and secured to the floor, to prevent a man slipping, with the possible result of serious injury due to getting his arm in the rapidly rotating machine.

Care should be taken not to operate dryers above their safe speed. Individual steam-driven centrifugal-dryers have burst with fatal consequences as the result of raising the plant boiler pressure. Where there is any likelihood of the boiler pressure being raised, a steam-pressure regulating-valve or reducing-valve should be placed in the line.

Vats and Pans Deep vats, or vats or pans containing hot liquids or acids, should be substantially fenced, or otherwise guarded, to prevent a man falling into or being splashed with acid.

Men working with acid should always be supplied with rubber gloves. Small water-tanks, always filled with fresh water, should be placed around in many places wherever acid is handled, so that whenever anyone is spattered with acid he may jump into a tank and wash the acid off before he is seriously burned. In places where the ground is soaked with acid the men working upon it should wear wooden shoes.

Loose Handles on Tools Handles on hand tools such as files, chisels, hammers, etc., should be kept tight. Loose handles on files have caused loss of eyes due to the tang flying up.

Stairways, Fire-Escapes, Doors, Etc. All stairways should be provided with substantial hand-rails on each side, unless one side of the stairway abuts against a wall, when a hand-rail on the side opposite to the wall is generally sufficient. If the stairway abuts against walls on both sides, at least one hand-rail should be provided. Any projecting nails or screws should be removed. If rubber or other strips are placed on the steps they should be secure and lie perfectly flat. All ragged carpet and oilcloth should be removed.

Fire-escapes should be secure and in good condition, and be kept clear.

Roller-suspended and sliding gates and doors should be carefully examined, to ascertain that they are secure and not liable to leave their track and fall or be blown down by the wind.

No loose material likely to be blown from the roof by the wind should be permitted to remain.

Sidewalks should be kept in good condition, and coal-hole covers and dead-lights properly fitted and kept in place.

A man should always be required to use a waist-strap or life-belt, or other form of suitable safety-device, when cleaning windows on the outside.

Slippery Floors Do not permit slippery stairs or floors. Many employees are injured by slipping on the floor of their working places. The floors should be kept as free as possible from water, oil, and grease. Men working around dangerous machinery should be provided with powdered rosin to put on the soles of their shoes, or to sprinkle on the floor.

Miscellaneous Guards and Suggestions Workmen exposed to poisonous dust, fumes, or gases, should be supplied with respirators to prevent inhaling these. There are a number of approved makes on the market.

Printing-press and power paper-cutter flywheels should always be fenced or otherwise guarded, especially when keys project from their hubs, which is too common. Hand paper-cutters should have a strip of sheet-metal placed in front of the knife, to prevent the fingers from getting under it.

Hand-wheels used for turning over or adjusting a machine when not running, often revolve at high speed when the machine is in operation. Such wheels are frequently found on printing-presses, envelope-making machines, certain machines used in paper-box making, automatic screw-machines, etc. A removable guard of wire mesh or other suitable material should always be fitted over such wheels. Sometimes the danger is accentuated by a projecting handle. This should be removed from the hand-wheels when possible, if the wheels revolve while the machine is running.

Care should be taken in approaching close to rapidly moving belts. Static electricity is likely to accumulate on such belts. When this electricity is discharged through the body of a person approaching the belt, he is likely to start suddenly by reason of the shock, lose his balance, and perhaps fall into or get caught in adjacent moving machinery. The danger is all the greater to an attendant standing on a ladder.

Melting-pots for type or stereotype metal should be covered with a hood provided with an exhaust-pipe having sufficient draft to draw the fumes to the outer air.

The molten metal in type-casting machines sometimes becomes clogged, with the result that it is driven out into the face of the operator. This should be guarded against by fastening a piece of sheet-metal just over the vent, so as to catch and divert the metal.

Fig. 46, reproduced through the courtesy of the "Museum of Safety and Sanitation" of New York, shows a mixing-machine safeguarded by a cover or grating which closes automatically, so that it is impossible, when the machine is in motion, for the workman to put his hand or arm inside.

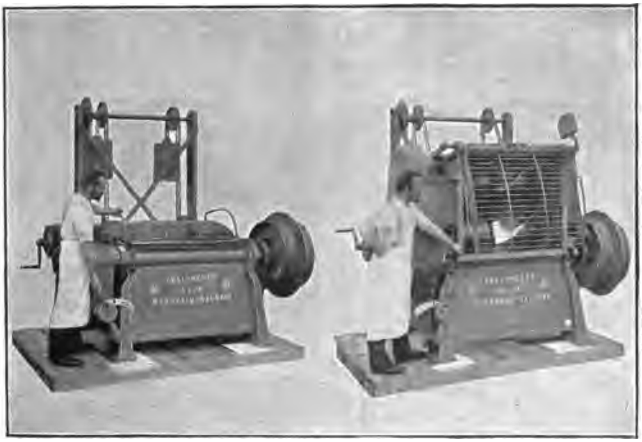


FIG. 46. MIXING-MACHINE GUARD

Fig. 47 shows a wheelbarrow-handle knuckle safety-guard of iron made by the Brown and Sharpe Manufacturing Company, Providence, R. I., for use in their works, to protect the knuckles of those who push barrows from being barked when passing through doorways. The cut is reproduced from the "American Machinist." Fig. 48 illustrates a detail drawing of the clamp itself, which is a simple casting arranged to clamp to the pipe handle of the barrow with a three-eighths inch U-bolt. This cut is reproduced through the courtesy of "Wood Craft."

In rubber mills it is customary to cut the rubber along the rollers with a small knife held in the hand. Should a man's hand catch in the rubber in this opera-

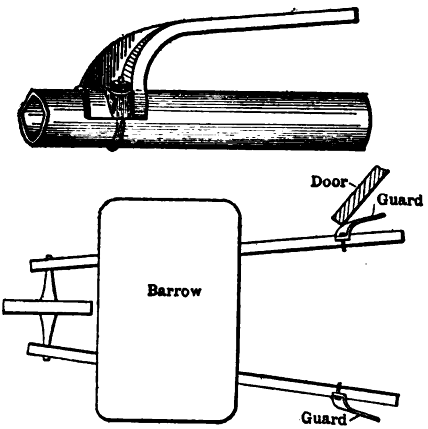


FIG. 47. KNUCKLE PROTECTORS FOR WHEELBARROW

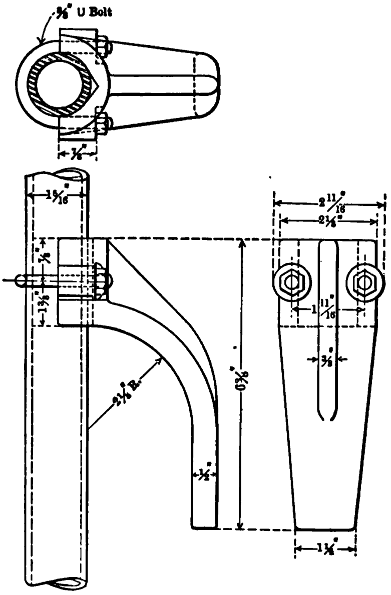


FIG. 48. DETAILS OF KNUCKLE GUARD

tion, his arm may be drawn in between the heavy rolls. To obviate this danger, the blade of the knife used for this purpose should be attached to a long handle, so that the workman's hand will not come near the rubber.

Heavy rotary grinders or pulverizers should have the sides of their pans high enough to preclude any possibility of a man falling in. Where the height of the pan is insufficient for safety, a substantial sheet-metal or wire-mesh guard should surround the grinder, as shown in Fig. 49. This cut is reproduced through the courtesy of the "Museum of Safety and Sanitation," of New York.

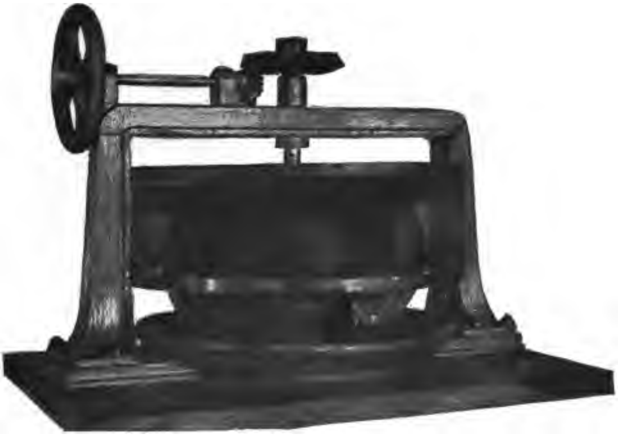


FIG. 49. GUARD FOR ROLLER MILL OR PULVERIZER

Wire straighteners usually bristle with projecting screws and run at very high speed. They may often be well guarded by a semi-circular sheet-metal cover.

The importance of piling castings, and laying down other heavy objects, so that they cannot fall over from any cause whatever, is shown by the large number of accidents that occur by the falling or tipping over of improperly piled or placed objects. Proper supervision of laborers engaged in trucking and piling castings, boxes, and other objects about the factory, and provision of proper storage devices for such objects, will do much to lessen the number of accidents of this character.

It is a common practice in shops to put cocaine in a man's eye the minute he gets a piece of steel or emery in it. This usually results in making the eye sore and inflamed for several days, and perhaps a week, due to the action of the drug. It is better not to use cocaine in a man's eye when extracting a chip unless the pain is too great to be borne.

Inspections and Rules All machines should be carefully inspected regularly, to make sure that they are in good order, and any worn or broken part should be immediately replaced or repaired. The use of broken or defective machinery should be forbidden, and its use after repairs should not be resumed until the superintendent or foreman has pronounced it to be in a safe condition. In furtherance of this idea, employees should be instructed to point out to their respective foremen the defective or dangerous condition of any machine or apparatus as soon as they discover it, and to make suggestions for the purpose of ensuring safety in the operation of the works. The men should be informed that prompt and careful attention will be given to such suggestions. It is useful to keep a sort of "mechanical record" in which the foremen may make entry of faulty apparatus or of anything else about the plant, or its conduct, which does not seem to them right or safe. In any event, the manager or superintendent should be immediately apprised of any unsafe conditions. A careful daily inspection of the works by the superintendent or his assistant is one of the best means of preventing accidents.

Emergency Hospital As accidents will sometimes happen in spite of all precautions, a thoroughly equipped emergency hospital room, or its equivalent, with a proper attendant, is advisable in all factories employing a large number of hands. Aside from the humanitarian aspect of such a hospital room, there is a decided advantage to production in avoiding loss of time by employees who receive minor injuries only.

Fire While fires cause many serious and fatal injuries, and it is therefore proper to discuss in a pamphlet on the prevention of industrial accidents the means of preventing fires, the subject is one that lies peculiarly within the province of the fire insurance companies.

These companies have devoted a vast amount of study to the prevention of fires, and have worked out practical rules for the construction and operation of works from the standpoint of fire prevention. Their rules of course deal with prevention as related to avoidance of property loss by fires, but they are equally valuable as related to avoidance of personal injuries by fires. The handbooks of the National Board of Fire Underwriters, setting forth these rules, are invaluable.* There are numerous valuable text-books. An excellent little pamphlet, bearing the title, "Fire Prevention and Fire Insurance," is published by The Hartford Fire Insurance Company, of Hartford, Connecticut. The subject is too extensive to be treated adequately here, and nothing will be attempted beyond a few brief hints regarding the more common dangers. These hints are as follows:

Most fires are caused by carelessness or neglect. Proper care and management are of the utmost importance. Eternal vigilance should be the rule.

Order and cleanliness make for safety. Many fires are due to untidy conditions. A careful inspection of the premises should be made daily, to be sure that all rubbish has been collected and disposed of.

Don't permit empty boxes and barrels, or other rubbish, to accumulate. Rubbish heaps are dangerous. Carelessly thrown matches or cigarettes may start a fire. It is best to clean up every day.

Ashes should be put in metal receptacles which should be emptied frequently.

Don't let oily waste lie around. It oxidizes rapidly, and spontaneous combustion is liable to ensue. This is likely also to occur with paper or rags saturated with printers' ink. Throw all oily waste and other rubbish into standard, metal, self-closing waste-cans, and remove contents of cans every night and burn.

Never use sawdust or other combustible material to catch oil drippings; use metal pans filled with sand instead. Don't use oil for lubrication of automatic cutting-tools; use soap solution instead if possible.

---

*Published by the National Fire Protection Association. They may be obtained from the National Board of Fire Underwriters, 135 William Street, New York City, or from the Underwriters' Laboratories, Chicago.

Forbid smoking on the premises by employees. Don't use sawdust in spittoons; use sand.

Avoid the use of parlor-matches; use safety-matches instead. The heads of parlor-matches will often fly in rubbing to ignite, and may start a fire or burn an eyeball badly.

Kerosene lamps should be filled by daylight only. No lamp should be filled while burning. Use only high-test kerosene. Don't use lamps burning gasoline or naphtha. Don't use kerosene to start fires. Don't store gasoline, naphtha, or other volatile oils in buildings; they give off vapors that are inflammable, and which, if mixed with air in the right proportions, form explosive gases that ignite readily.

Gas-jets should be rigid, or otherwise so arranged that they cannot swing against woodwork or other combustible material. If the overhead clearance between a gas-jet and a combustible ceiling or combustible material is less than three (3) feet, there should be provided a heat deflector, having preferably the form of a metal bell, which should be suspended over the jet at least four (4) inches below the ceiling or material exposed. In no case should a jet be less than eighteen (18) inches under inflammable material, even where a heat deflector is provided. All woodwork or other combustible material on walls behind gas-jets and within one (1) foot should be protected by a sheet of asbestos-board and tin, with an air space. In no case should a jet be less than eight (8) inches from combustible material on walls, columns, etc., even where a shield is provided. The use of lava tips is inadvisable, as these tips are liable to be jarred out and the long flame that then issues from the opening may ignite any adjacent combustible material. The various forms of mantle lamps and of enclosed burners are preferable. If a swinging gas-bracket is used, provide stops so arranged that the bracket cannot swing far enough to bring the flame into contact with combustible material. Flexible or rubber-tube connections are dangerous, and should be avoided wherever possible. If flexible connections must be used, put the turn-off cock where the tube joins the gas-pipe, not at the burner. If the smell of gas is noted, open doors and windows and ventilate thoroughly. Don't hunt for the leak with matches, candles, or other naked lights.

Don't overload the electric-light system, and don't let deterioration from age and use proceed too far before renewing. Have all construction in accordance with the rules of the National Board of Fire Underwriters. Put spark-arresters around all open arc lights. Don't allow incandescent electric lights to rest on combustible material. Don't drape or hang anything combustible on electric-light bulbs. Don't use long flexible cords, and don't shorten or adjust cords by looping them over nails or the metal parts of machines. Paper shades should not be used. Never replace blown-out fuses with wire.

It is a wise precaution to have gas and electricity turned off from premises when closed for the night.

Lightning rods are generally advisable on country buildings, on isolated buildings, and on all buildings having tall chimneys, steeples, peaked or gable roofs, and flag-poles. Copper or iron make satisfactory conductors. Conductors need not be insulated, but they should have as few joints as possible and no sharp bends or loops, and should be fastened securely. A good ground is essential, connection with underground water-piping being preferable, but where this is not possible, ground-plates or castings should be used. Conductors should be protected from corrosion.

Stove-pipes should be run direct to chimneys, and never through floors and partitions. Floors under and above stoves should be protected by brick, cement, or sheet-metal. All woodwork near stoves should be protected by metal.

Wood in contact with hot-air pipes and steam-pipes will char and then take fire readily, or even ignite spontaneously. Wood within two (2) feet of hot pipes should be protected by asbestos and tin, with air spaces if possible.

Inspect chimneys at regular intervals and repair defects.

Make roofs, cornices, etc., of fireproof material. Use wire-glass in windows and sky-lights.

Build fireproof as far as possible. Don't scant in equipment with fire-doors, shutters, etc. Automatic sprinklers are advisable in many situations. The valves in sprinkler supply-pipes should always be kept open. Keep fire-doors and shutters in good repair. Test automatic doors every day. Close fire-doors and shutters every night, and on Sundays and holidays, and any other times that the building is not occupied.

Provide plenty of fire-pails filled with water, and don't permit them to be used for any other purpose. Provide pails of sand ready for use wherever inflammable liquids, such as gasoline, naphtha, etc., are used; water will only spread the fire. Chemical fire extinguishers and inside stand-pipes with hose are requisite for many buildings.

Wet down shingle roofs, lumber piles, etc., in dry summer weather, and also when fireworks are to be set off in the neighborhood.

Watch stored coal carefully for signs of heating. Spontaneous combustion is liable to occur, especially if the coal is wet. Spontaneous combustion is likely to occur also in damp lampblack and charcoal.

Provide ample metal fire-escapes, or build the stairways in fireproof shafts. In case of fire a panic is likely to occur, so that the means of exit should be sufficient to let out all employees quickly. Keep the fire-escapes absolutely clear; don't let anything be put upon them.

All doors should be made to swing outward. This is especially important in the case of public buildings. The exits should be marked by signs that quickly catch the eye, and at night by red lights.

In non-fireproof buildings, the elevator shafts and the shaft-doors should be constructed fireproof, the shafts either of brick or of metal-framing filled in with hollow tile and carried up solid from floor to ceiling, and the doors when closed filling the opening to the shaft completely. Any lights in the shaft or doors should be provided with wire-glass.

Caution in the Use of Naphtha, Gasoline, Etc. The following set of rules governing the use of naphtha, gasoline, etc., is reproduced from placards posted about the works of the Brown and Sharpe Manufacturing Company, Providence, R. I. The same or similar rules should be enforced in all factories where these substances are used:

"NOTICE"

"Great care should be taken in the use of naphtha. It is a volatile and very inflammable fluid. It will take fire at a distance of several feet from a light, and its flame cannot be extinguished by water.

"No more than is absolutely necessary should be used. Not more than one-half pint should be used at any one time and the large receptacle containing naphtha should be thoroughly closed before any attempt is made to use the half pint, or smaller quantity.

"Should it appear necessary to use more than one-half pint, a written order should be received from the foreman, and before writing such an order, he should confer with the Superintendent.

"After the gas is lit, naphtha should not be used without the consent of the foreman, and it can then be obtained only on a written order."

Wherever inflammable liquids are used, pails of sand should be kept ready for use in case of fire. Water is apt to spread the fire.

Dust Removal Means should be taken to keep the factory as free of dust and fumes as possible. Constant breathing of air laden with iron, brass, and many other dusts, often leads to tuberculosis in a very short time. Experience has shown that mechanical means are absolutely necessary to ensure proper removal of dust. Wherever dust or fumes are formed locally, as, for instance, by tumbling barrels, grinding and polishing wheels, circular saws, furnaces, etc., the exhaust should be direct from hoods which enclose the objectionable source as completely as possible. The design of an exhausting system is a matter that should be entrusted to an expert in that line or to the blower manufacturers, and not to a local tinsmith, if efficient and economical results are to be obtained.

Dust Explosions The necessity of providing proper appliances for dust removal becomes imperative wherever the dust is of such character that a quantity of it suspended in the air in the right proportions forms an explosive mixture. This is the case in explosive factories, grain elevators, flour mills, saw mills, planing mills, box factories, etc. In a flour mill, for instance, a piece of wire or a nail getting into a grinder may cause a spark, which under favorable conditions will ignite the flour dust in the air and cause a disastrous explosion. As moisture in the air lays dust, and also very materially lessens static discharges from belts, etc., the advisability of moistening the air suggests itself. This may be done by the introduction of warm moisture-laden air by the use of a humidifier, or by allowing jets of steam to escape into the mill room where most of the dust is made. The latter device could probably be arranged to advantage without permitting any of the flour stock to become moistened, by allowing only sufficient steam to escape to dampen the atmosphere. Both of these methods are in common use for moistening the atmosphere of the card rooms in textile mills.

In connection with this subject, the following quotation from the January, 1909, issue of the "American Machinist" is of interest:

"An overlooked factory danger has been pointed out in Germany by Prof. M. M. Richter, who has found that machinery belts—especially in dry air and when rubbed with resinous substances—may become highly charged with electricity, and may give off sparks that, in an atmosphere laden with dust or combustible vapors, may produce a serious explosion. A five-inch belt running over a wheel making 600 to 2,000 revolutions a minute gave off a spark one to one and a half inches long. Coating the belts with bronze or aluminum powder proved an ineffective preventive, but acid-free glycerin, applied once a week, attracted moisture, and not only gave security against static charges, but increased the life of the leather."

Design of Safety Devices In so far as possible, the design of all safety devices should be such that any accident that may happen to the device will make the appliance to which it is attached more safe, not less safe. A notable example of proper design from this standpoint is the air-brake on railroad trains. Any failure in the train-pipe sets the brake and brings the train to a standstill. A breakdown of a safety device should have the effect, when conditions admit of such arrangement, of making it impossible to use the tool or appliance on which the device is placed.

All suggestions in this pamphlet regarding safety devices proceed on the assumption that the design, material, and construction, shall be first-class in every respect. If poor material is used, the best design may fail in its purpose. A blow-hole in a casting used in a safety device may make the device itself a source of danger instead of a safeguard.

Signs Advantageously Used in Shops

"Notify the engineer before doing any work upon main-line shafting, pulleys, or belts, while engine is stopped."

"Do not talk to man operating this machine."

"Whoever uses this machine without the guard, uses it at his own risk."

"Pick up all loose nails or boards with nails in them and deposit them in the cans provided for that purpose." (Running a nail in the foot is a common accident and one that often leads to serious consequences by reason of the blood-poisoning that often ensues.)

"Riding on hand-trucks in this department is strictly forbidden."

"Do not step through a belt under any circumstances."

NOTE—Figs. 27, 28, 29, 39, and 40, on pages 137 and 150, are reproduced by permission from Calder's "The Prevention of Factory Accidents," London, 1899 (Longmans, Green & Co., New York and London).

Wood-Working Machinery

Danger The machinery used in wood-working is exceedingly dangerous. It is important therefore that the utmost care be exercised in its operation and that all practicable safeguards be utilized.

Belts Owing to the usually high speed of belts on wood-working machinery and the commonly exposed positions of such belts, they are a constant source of danger to the machine hands. Loose clothing catches easily on these belts and the pulleys over which they run, and serious, and often fatal, accidents are caused thereby.

The greater number of such belts and pulleys can be readily guarded, and guards should be provided wherever they are feasible. Where it is necessary that the guarded parts shall be easily accessible, the guards may be so constructed as to be removable. Guards should also be put over exposed gears, sprockets, and chains (See pages 131, 137, and 141, in the chapter on "The Factory").

Rubber Mats Owing to the smoothness of the floors in wood-working shops, there is always the danger of the machine hand slipping and falling on the machine he is operating, especially when working on a heavy piece. A rubber mat placed in front of the machine and secured to the floor is one of the best safeguards against such accidents. The mat should be kept free from sawdust and renewed when torn or badly worn, else it will fail to accomplish the purpose for which it is provided.

Rubber mats are useful in preventing accidents when placed in front of circular saws, band saws, planers or jointers, shapers, and all machines of like character.

Circular Saws The dangers incident to the use of circular saws are too well known to require description.

A "riving knife" or "spreader," when properly attached to the table immediately back of the saw, will spread the cut sufficiently to prevent cramping of the saw. It is very important that cramping shall not take place, as it usually stops the saw and throws the belt off, or throws the work back on the operator, often with serious results.

The riving knife itself is simply a piece of sheet-steel mounted in a vertical position back of the saw and preferably curved to conform somewhat to the outline of the saw. The edge nearer the saw should be a little thinner than the saw itself, so that the saw cut will slide over it easily. The opposite edge should be at least the thickness of the saw, and it is even better to have it a slightly greater thickness. The length of the knife will, of course, depend upon the size of the saw with which it is used. Fig. 50 shows the general scheme of the appliance.

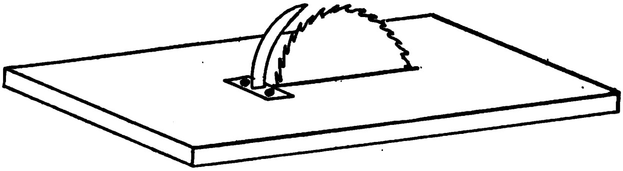


FIG. 50. RIVING KNIFE

A very simple device that will often prevent the work being thrown back in case of cramping, consists of a board 4 or 5 inches in width fastened perpendicularly to the ceiling directly over the saw and of such length that its lower end will just clear the saw. The plane of the board should be at right angles to that of the saw.

If a saw without a guard is permitted to run while the operator is away from it, a small oblong wooden box placed over the saw will serve as a safeguard to persons passing the table. If practicable, this box or cover should have a dowel pin in each end, and these pins should fit into holes in the table.

Saw Guards The use of saw guards is strongly recommended. The object of these devices is to prevent the operator's hand coming into contact with the saw in case either the work or his hand should slip. Brief descriptions and illustrations of a few practical saw guards are given in the succeeding paragraphs, and these, or similar guards serving the same purpose, should always be used.

A saw guard* which automatically adapts itself to different thicknesses of material is shown in Fig. 51. Being attached to the ceiling above the saw, it leaves the table clear for wide work, and in the case of bevel work, as shown in the cut, it is always in position, no matter how the table is tilted. It is also adjustable lengthwise on the table for combination saws. The guard may be raised, moved to one side, and held there by the hand-wheel while changing saws, making repairs, etc., or while doing high end-work, as in Fig. 52. No tools or wrenches are needed in its adjustment. The small dog or digger on the back of the guard holds the board so that it cannot catch on the saw and fly back and strike the operator.

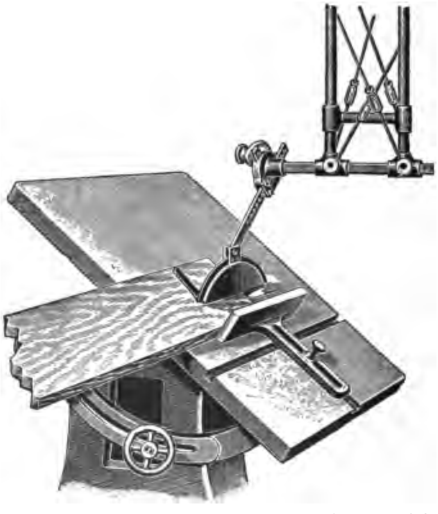


FIG. 51. CIRCULAR-SAW GUARD—Working position

The maker also furnishes this guard omitting some of the adjusting devices shown. It will serve its purpose equally well then if the work is not too variable.

Fig. 53 shows a guard† which combines the riving

---

*Patented
†Patented

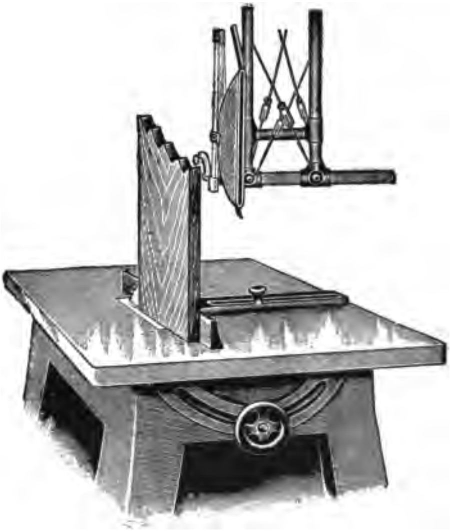


FIG. 52. CIRCULAR-SAW GUARD—Swung up for high end-work

knife with the guard. It is adjustable, to accommodate saws of different sizes. Like the guard described in the preceeding paragraph, it is provided with a device to prevent the board rising on the teeth of the saw and kicking back at the operator.

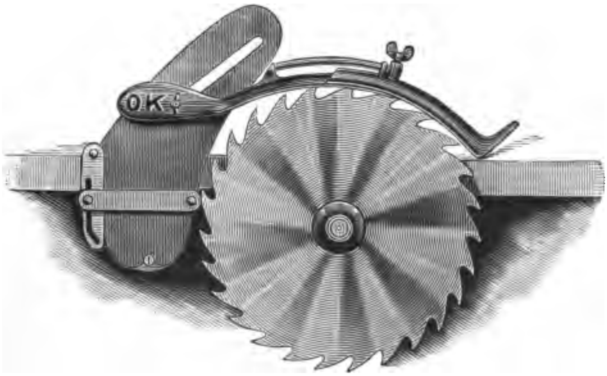


FIG. 53. CIRCULAR-SAW GUARD

Two forms of saw guard* which also combine the riving knife with the guard are illustrated in Figs. 54 and 55. The former is adjustable in all positions by one thumb-screw.

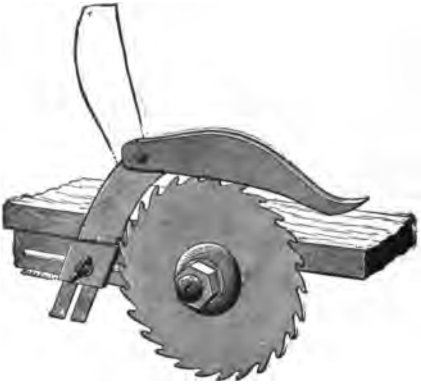


FIG. 54. CIRCULAR-SAW GUARD

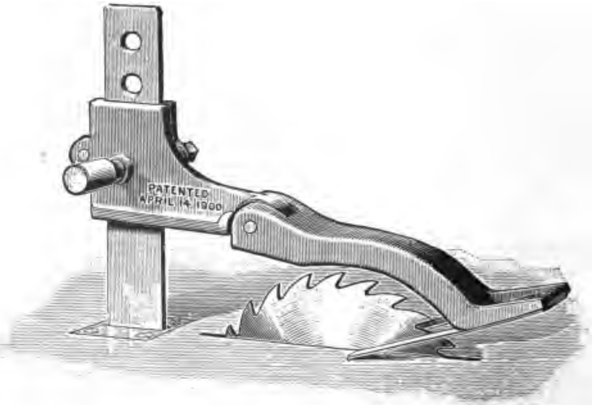


FIG. 55. CIRCULAR-SAW GUARD

Unless included in the construction of the guard itself, care should be taken to provide a well secured riving knife in conjunction with the guard wherever the nature of the work will permit.

---

* Both patented

The closing by movable doors or lids of all openings in the bench to the lower part of the saw should be invariably carried out in every form of the tool.

Guard for Cross-Cutting Saws At benches used only for cross-cutting, the guard may take a very simple form. Fig. 56 shows a hood which is very serviceable. It may be made of sheet-metal, wire netting, or wood. The hood is over-hung from the back, where it is secured to a hinge screwed into the bench. The work may be fed either by hand or by a sliding-gauge table.

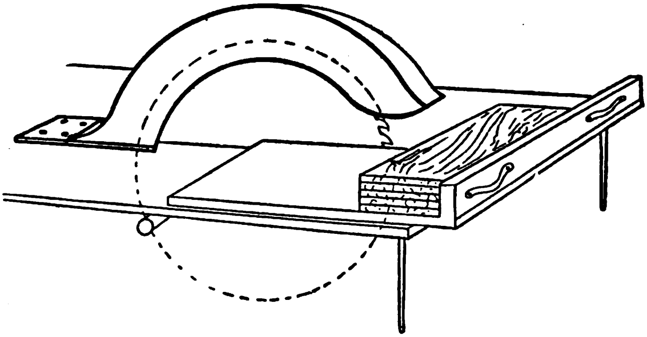


FIG. 56. CROSS-CUTTING SAW GUARD
(See note on page 185)

Swing Saws Swing saws should invariably have a cast-iron or sheet-metal guard over the top of the saw and be provided with counter-balances on the swing-bar, to throw the saw back from the workman. The arrangement should be such that the counter-balances, which are generally made adjustable, cannot slip off the swing-bar. There should be a positive stop at the end of the bar. The slipping off of a counter-balance, due to a set-screw working loose, recently cost a workman his right hand; when the counter-balance slipped off there was nothing to hold the swing-bar and the saw swung against the man with the result stated.

Band Saws Both the upper and lower wheels of a band saw should be completely guarded. For this purpose a wire grating, a sheet-metal covering, or a wooden housing, around the wheels, may be used. With these in place, it is impossible for the workman to get his hand or foot caught in the spokes of the wheels. In case the band saw breaks and flies, as it usually will sooner or later, these guards will, as a rule, prevent the saw from striking the operator or other person standing by.

Another place which should have more efficient guards than those usually provided by the manufac-

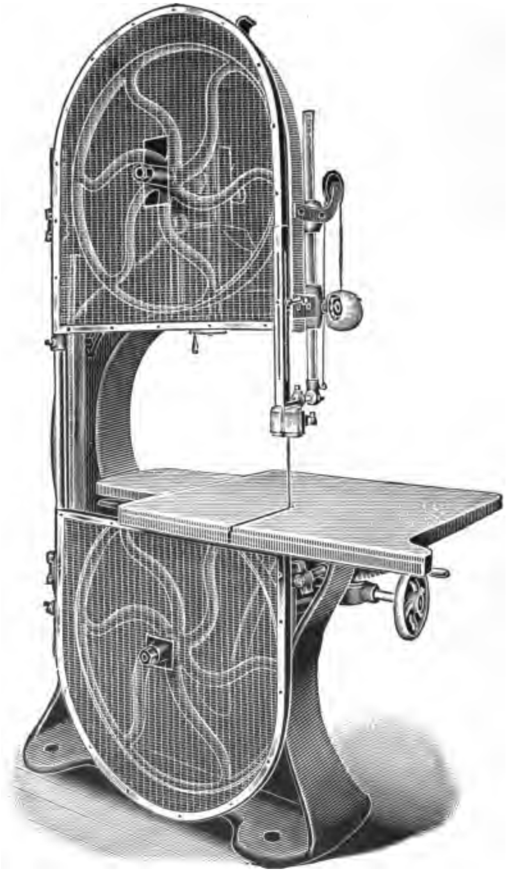


FIG. 57. BAND-SAW GUARD

turers, is the idle part of the saw between the wheels, on the left-hand side of the machine. The saw at this point commonly runs close to a wooden strip placed on one side of it as a guard. While this guard is useful in a measure, it is hardly sufficient. The guard should either cover the face of the saw, or enclose it closely on both sides. Tubing may also be used effectively to guard the vertical portions of the saw not used in cutting.

Fig. 57 shows a band-saw guard* devised to attach to the frame of the machine. It has adjustable joints, so that it may be easily attached to any style of machine. The guard consists of an angle-iron frame covered with heavy wire screening. A sliding-piece guarding the working portion of the saw, rises and falls automatically with the saw-guide, so that the only portion of the saw necessarily exposed is that for a height above the table equal to the thickness of the work.

Buzz Planers or Jointers The hand planer or jointer is a most dangerous machine when operated without a guard. In using it, accidents often occur in unexpected ways. A change in the grain of the wood, the striking of a knot, or too heavy a cut, may hurl the piece from the machine and throw the workman's hands into the knives.

A workman should always try a jointer before using it. The knives may be set to take too heavy a cut, with the result that the piece is hurled back on him. In using a jointer, the operator should not allow his hands to rest on that portion of the stock over the knives if it is possito avoid doing so.

Yet a jointer may be simply and easily guarded, so as to render it safer than many other wood-working machines. Illustrations and brief descriptions of some serviceable guards follow:

The first guard,† Figs. 58 and 59, is made up of a number of interlocking sliding sections or shells, by which the length of the guard is changed to suit the length of the knives exposed. It is attached to the machine by a bracket and two cap-screws. The round rod passing through the bracket is held in position by the hand-screw, which makes the guard adjustable, without

*Patented
†Patented

the use of a wrench, for facing off different thicknesses of material. In operation the piece passes under the guard and the workman's hands pass over it, as shown in Fig. 59. The operator's hands are thus protected should the board be hurled from the knives. The guard may easily be telescoped and lowered down to the side of the machine when the machine is to be used for rabbeting, or

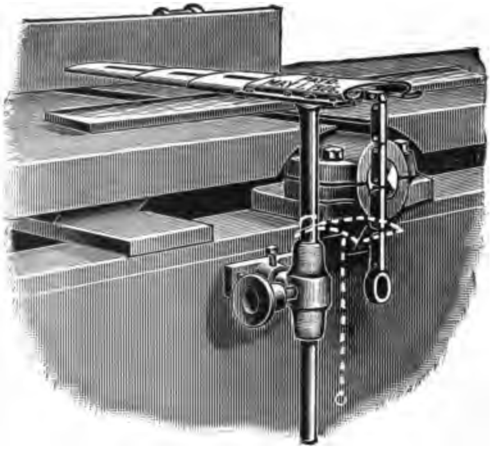


FIG. 58. JOINTER GUARD

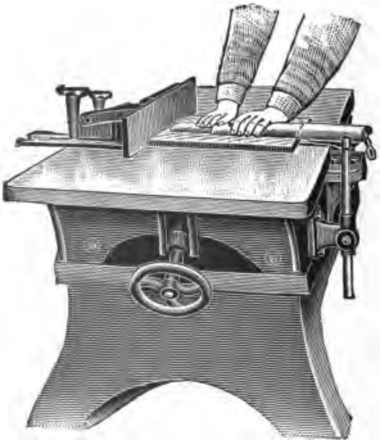


FIG. 59. JOINTER GUARD

during repairs, etc., as shown by the dotted lines, so that it need never be detached from the machine.

Fig. 60 shows a guard* somewhat similar to that described in the preceding paragraph, in which the knives are covered by a flat slide adjustable to and from the fence. It is supported by a round standard, which slides in a bracket attached to the side of the machine, to allow of vertical adjustment for different thicknesses of stock. The standard is flattened on one side and an eccentric clamping device operated by a lever tightens on this flat side, bringing the guard straight over the knives and holding it firmly. This guard also may be dropped to the side of the machine when necessary, as shown by the dotted lines.

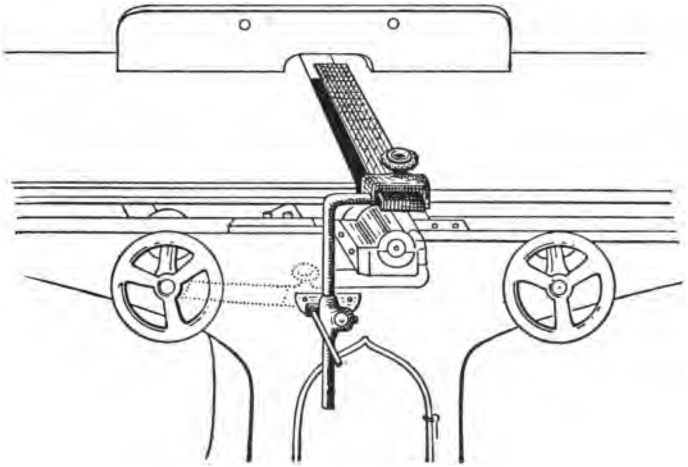


FIG. 60. JOINTER GUARD

Figs. 61, 62, and 63, illustrate another form of guard† in which the work passes under, and the operator's hands over, the guard. It is attached to the machine by a small bracket having a square hole through it; within this hole slides a square shaft, M, Fig. 2 of Fig. 63, which is held in any desired position by the hand-screw, L. By means of the horizontal shaft, D, the guard may be slid to and from the jointer fence. The guard rests on the piece, a roller, G, being placed in the under front section of it to relieve the friction caused by its weight (5 lbs.) on the lumber. As the finished section of the lumber slides over the back-table it comes into contact with a roller, K, on the end of a spring-finger which holds the lumber down on the table, this finger being quickly adjusted to any desired position.

---

* Patented

† Patented

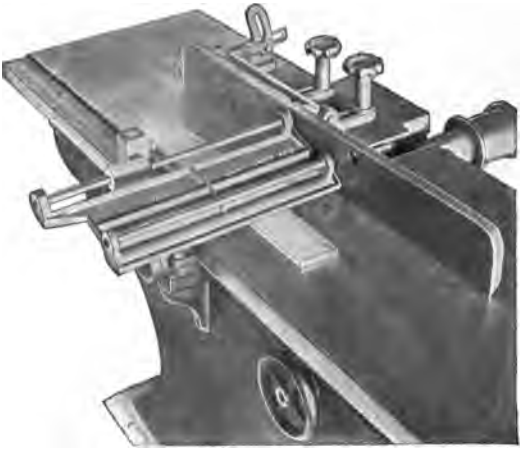


FIG. 61. JOINTER GUARD

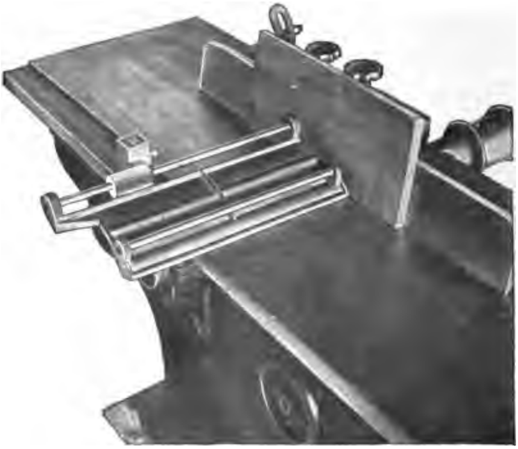


FIG. 62. JOINTER GUARD

When planing lumber on edge, the guard may be easily pulled away from the fence, as in Fig. 62.

If the lumber should be hurled suddenly from the knives, the workman's hands cannot be thrown into the knives—so the maker states—for the moment the lumber passes from the front of the guard in either direction, the guard will immediately drop to the top of the table.

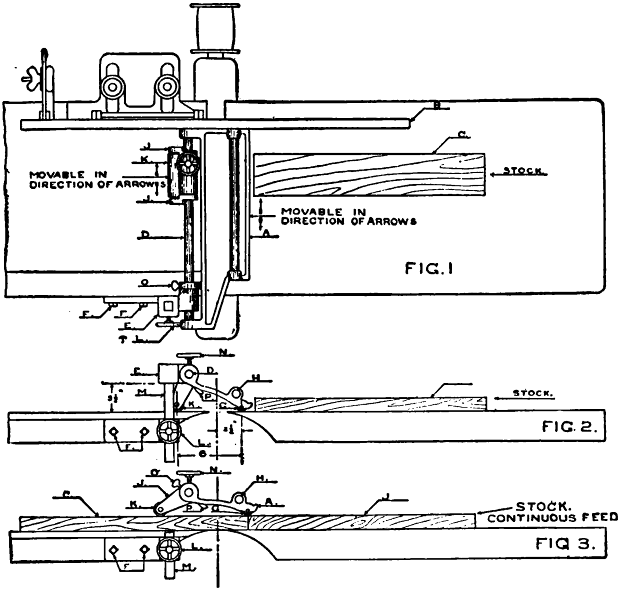


FIG. 63. JOINTER GUARD

Where there is much work to be done of about the same thickness, a locking-device may be used. This is designated P, in Fig. 3 of Fig. 63, and is controlled by the thumb-screw, O. This will allow the lid, A, to rest on the stock but never to drop to the table; the stock entering under it will come into contact with roller G, and lift the lid about $^1/_{16}$ inch, thus placing the tension of the spring in spring-fingers on both ends of the stock. Then the operator need only push the stock through, backing up one piece by another, as shown. His hands in such case are far enough from the knives to prevent possibility of injury.

Figs. 64, 65, and 66 show three positions of a somewhat different type of guard.* This guard consists of an arm, one end of which is hinged or pivoted at the side of the table near the operator. The other end, to which is attached a flexible cover or shield, extends over the knives, so that when no work is being done this flexible shield covers the knives, as in Fig. 64. The piece to be planed is handled in the usual manner. As the work goes forward it pushes the arm, with its attached flexible cover, to one side, as in Fig. 65. As soon as the piece has passed the knives the arm springs back into place, as in Fig. 66. A small attachment is furnished, if desired, to hold the guard open when lumber of a given invariable width is to be surfaced continuously. The guard can be put out of operation, if necessary, without removing it from the machine, by slipping it under the roll on which the flexible portion slides.

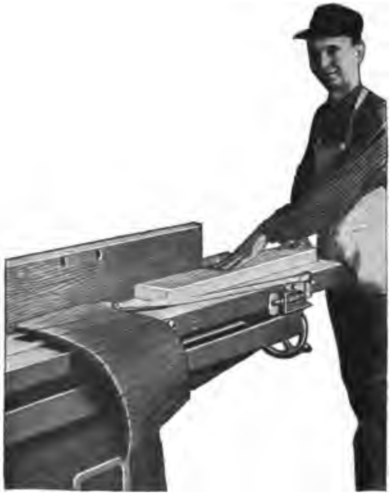


FIG. 64. JOINTER GUARD—Position 1

Fig. 67 shows a guard† which in principle of operation resembles the preceding. By reason of the shape of the guard-plate and the arrangement of the spring, an

---

* Patented

† Patented

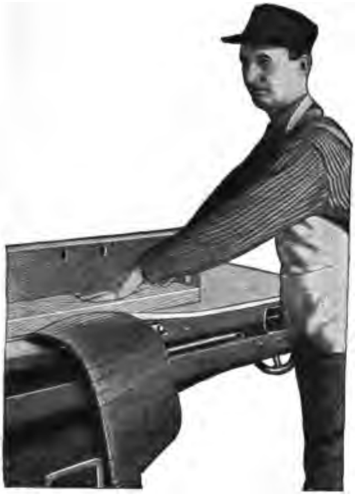


FIG. 65. JOINTER GUARD—Position 2

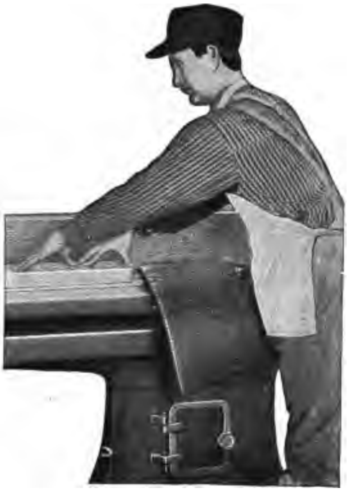


FIG. 66. JOINTER GUARD—Position 3

even tension for wide or narrow material is obtained without change. For rabbeting and dadoing, the guard-plate is lifted out of pin socket.

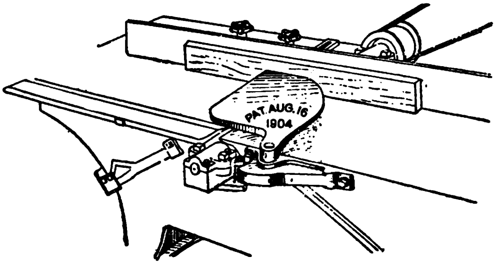


FIG. 67. JOINTER GUARD

If none of the foregoing, or similar, devices are available, a helpful home-made guard of sheet-metal may easily be made and attached, when the work is at all uniform in width, so as to cover most of that portion of the planer-knives not covered by the work.

Many accidents may be prevented by keeping the gauge of the machine set close to the edge, only exposing a sufficient length of the knives to clear the width of the stuff being worked. Where the planer is much used, however, this may be found impracticable, owing to the too quick dulling of the knives.

Wood-Shaper Guards A continually increasing recognition of the danger attendant on operating a wood shaper without a guard, has resulted in the invention of a number of suitable guards, several of which are described in the following paragraphs. By the use of such guards, or similar ones, the shaper may be rendered reasonably safe, and it should never be operated without such a guard.

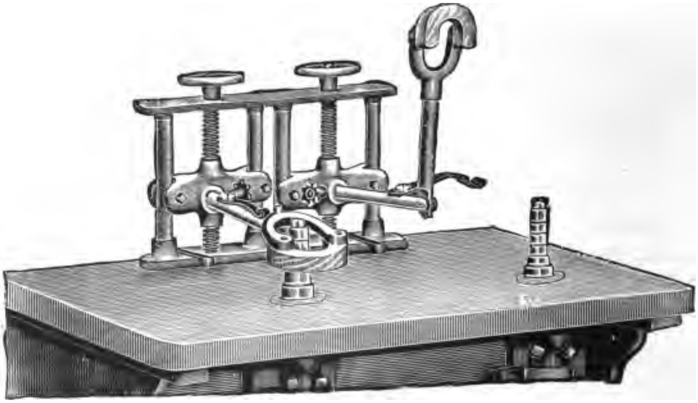


FIG. 68. WOOD-SHAPER GUARD

Fig. 68 shows one form of shaper guard.* The arm is jointed to permit of its being raised for dropping inside-work over the spindle, changing knives, etc. The height of the arm may be so adjusted, if desired, that the spring which holds it down will put pressure on the work. The hand-wheel and screw allow independent adjustment of the arm for each spindle.

The base of the guard is hinged at the back edge of the table-top, so that, if necessary, the guard may be turned back out of the way, clearing the whole top of the machine, yet leaving the guard attached to the machine.

The forked piece around the spindles is made in duplicate and in different sizes, so that one may be removed and another put on, to suit the particular work. It may be fitted with other wood shoes for special work, to suit the convenience of the user.

---

* Patented

The maker also furnishes this guard omitting some of the adjustments, if desired, as shown in Fig. 69. It will serve very well thus where the work is not too variable.

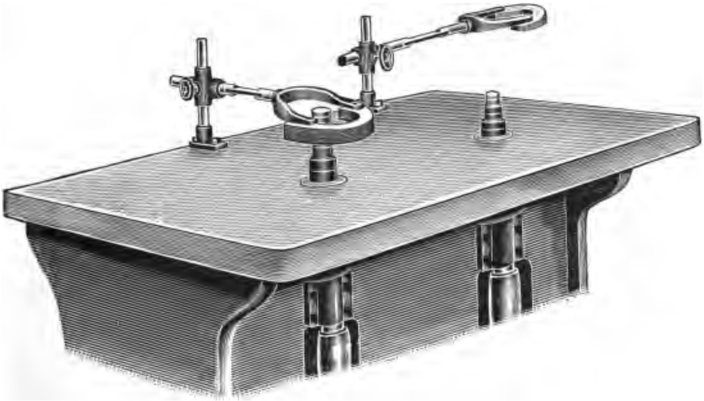


FIG. 69. WOOD-SHAPER GUARD

Figs. 70 and 71 show two other makes of guard,* both of which are attached to the table behind the spindle, out of the way. These, like the guard just described, are

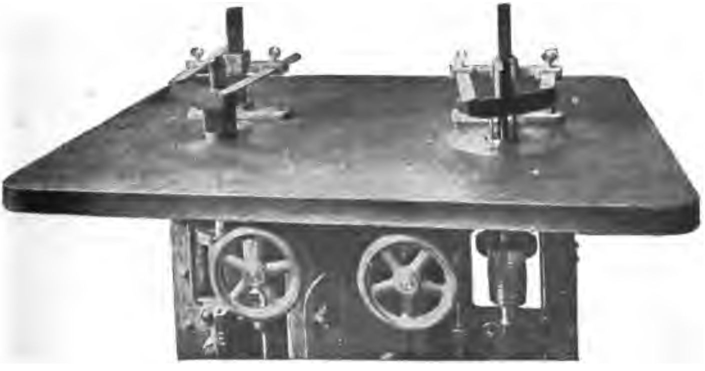


FIG. 70. WOOD-SHAPER GUARD

---

* Both patented

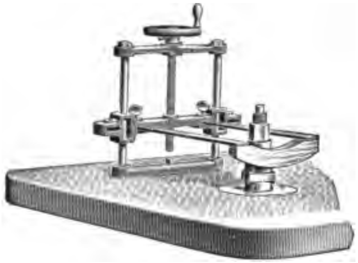


FIG. 71. WOOD-SHAPER GUARD

adjustable both as to height and as to various diameters of cutter-heads.

A somewhat different form of shaper guard is shown in Fig. 72. This consists of a metal ring several inches in diameter, which forms the bottom of a wire cage of sufficient height to allow the spindle to clear when it is adjusted close to the work. Two tubes, one of which telescopes into the other, will afford a convenient means of suspending this guard from the ceiling.

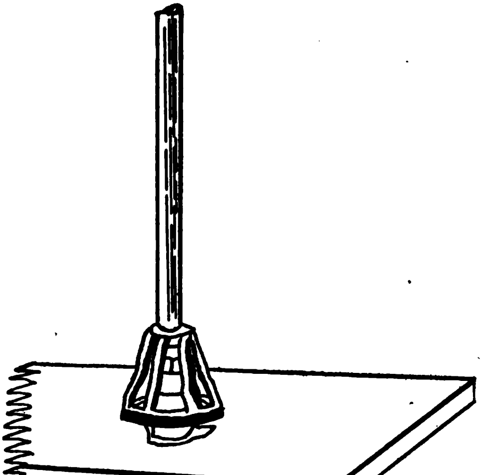


FIG. 72. WOOD-SHAPER GUARD

Miscellaneous Machines

Projecting set-screws on drill-spindles are dangerous. They should be replaced by hollow screws which set flush with or below the surface, as described on page 135 in the chapter on "The Factory." Bevel-gears on drills should be covered by suitable guards. If the drill is one that runs continuously, and that slides up and down on a keyway, it is well to have it recede into a piece of pipe when not in use. This will prevent it catching in the clothing of anyone passing.

Projecting set-screws on the rollers of tongue- and groove-making machines should also be replaced by hollow screws which do not project from the rollers, as referred to in the preceding paragraph. In feeding these machines, the operator's sleeves often come close to the rollers, and a serious accident may result from his clothing catching.

Useful Signs

The use of the sign already mentioned in the chapter on "The Factory,"—"Whoever uses this machine without the guard, uses it at his own risk,"—is particularly appropriate in connection with wood-working machinery.

NOTE—Fig. 56 on page 173 is reproduced by permission from Calder's "The Prevention of Factory Accidents," London, 1899 (Longmans, Green & Co., New York and London).

Index

PAGE
Accidents, causes of 1
    due to carelessness 6
    due to failure to use safeguards provided 7
    due to ignorance 6
    due to insufficient lighting 5
    due to intoxicants 7
    due to overcrowding of machinery 5
    due to overwork 7
    due to unsuitable clothing 6
    financial loss due to 1
    means of prevention 2
    percentage of preventable 2
Air-compressor cylinders, lubrication of 88
Air cushions, elevator 123
Alarms, low-water 28
Automatic circuit-breakers 77, 92
    cut-off valves, boiler 27
    doors, elevator 109
    elevators 123
    lubricating devices 88
    stop-motions, elevator 118
    vacuum-breakers 77
Bale hoists, guarding of 143
Band-saws, guarding of 173
Belt lacings 139
Belt-shifters 141
Belting 137, 156, 168
Belts, guarding of 58, 137
    shipping 139
Bisulphite digesters 56
Blowers, guarding of 53, 145
Boilers, blowing down 52
    blow-off pipe protection 32
    blow-off pipes and connections 30
    blow-off, surface 32
    braces 24
    calking 25
    circulation of water in 20

Boilers, cleaning 40, 49
- compounds 41
- corrosion 43
- cracks 16, 54
- cut-off valves, automatic 27
- domes 21
- dry-pipes 21
- explosions 10
- feed-water connections 32
- flanges 25
- forced firing 53
- fusible-plugs 28
- gauge-cocks 34
  - do. glasses 34
- hammer tests 55
- hand-holes 23
- hydrostatic tests 55
- incrustation 35
- internal inspections 46
- laying up 44
- low-water alarms 28
- man-holes 22
- material for 15
- oil removal 40, 44
- patches 54
- power cleaners 43
- precautions in entering 45
- rivet-holes 19
- room 14
- safety-valves 25
- scale 35
- seams 16, 24
- setting tubes 20
- specifications 14, 15
- stay-bolts 25
- steam-gauges 30
- stop-valves 26
- strength 17
- water-column connections 34

Boiler-room, in general 14
- rules 47
  - do. additional 50

Braces, boiler 24

Cables, electric 93
    elevator 110
    sizes of sheaves for 116
Calking of boiler seams 25
Carelessness 6
Centrifugal dryers 154
Chains 143
Circuit-breakers, automatic 77, 92
Circuits, grounding 94
Circular saws, guarding of 168, 169
Circulation of water in boilers 20
Cleaners, power 43
Cleaning, boilers 40, 49
    machinery 131
Clearance, piston 81
Clothing, unsuitable 6
Cocaine in eye, caution in use of 159
Compounds, boiler 41
Connecting-rods, guarding of 58
Corner-staying machines 152
Corrosion of boilers 43
Counter-weights, elevator, guarding of 121
    do. strapping of 119
Couplings, shaft 136
Cracks in boilers 16, 54
Cranes 142
Cylinder, removal of air from elevator 119
Cylinders, lubrication of air-compressor 88
    lubrication of elevator 118
Dangerous conditions, employees to point out . . 160
Digesters, bisulphite 56
Domes on boilers 21
Drains, engine 83
Dryers 56
    do. centrifugal 154
Dry-pipes in boilers 21
Dust, explosions 165
    removal of 165
Dynamos, guarding of 90
    oiling and cleaning 91
Electrical apparatus and cables, when dangerous painting red 93
Elevator operators, age of 126
    in general 126

Elevator operators, rules for 127
Elevator rules, additional 129
Elevators, air cushions 123
  air in cylinder 119
  automatic 123
  automatic or self-closing doors . . 109
  automatic stop-motions 118
  cables 110
  care of electric 125
  car-locking device 110
  conditions of use of 109
  counter-weights, guarding of . . . 121
    do. strapping 119
  guards on car 100
  guides, care of 118
  hand-ropes 113
  interlocking-devices for shaft-doors and car . 106
  lifting capacity of 124
  locking-devices 107
  lock-nuts on valve-stems 117
  lubrication of hydraulic cylinders . . 118
  overhead gratings 104
  piston-rods, examination of . . . 122
  position of machine 118
  pressure-tank, equipment of . . . 123
    do. examination of . . . 123
  protection of shafts 101
  rest for safe-lifting 110
  rules, additional 129
    do. for operators 127
  safety-devices 105
    do. care of 106
  sheaves, for cables 116
    do. fastening and care of . . 116
  sidewalk 104
  speed of 124
  useful signs on and about 130
  warnings 104
Emery wheels 145
Engine operation, notes on 86
Engine-room floors 59
Engines, automatic lubricating devices . . . 88
  piston clearance 81

Engines, racing of 62, 69
Expanders, tube 20
Explosions, boiler 10
  dust 165
  flywheel 67
Extractors 56, 154
Factor of safety, boilers 19
  elevator cables 114
  engines, on speed 62
  do. on strength 62
Failure to use safeguards provided 7
Fans, guarding of 53, 145
Feed-water connections 32
  heaters 41
Finger protectors 153
Fire escapes 155
  in general 160
First aid in cases of electric shock 96
Flanges, boiler 25
Floors, engine-room 59
  slippery 5, 156
Flywheel accidents, causes of 67
Flywheel rims, availability of various materials for . 65
  efficiency of joints 62
Flywheel speed, temptation to increase 67
Flywheels, design of 65
  function of 60
  guarding of 58
  inspection of 77
  rim-joints of 62, 66
  safe speeds for 60, 63
Forced firing of boilers 53
Fuses, electric 92
Fusible-plugs 28
Gasoline, care in using 164
Gauge-cocks 34
Gauge-glasses 34
Gauges, pressure 30
Gearing, guarding of 141
Governor, inspection of 77
  stops 69
  guard 59
Grinders, guarding of 159

Grindstones 145
Grounding low-potential circuits 94
Guarding machinery 131
Guards, miscellaneous 156
  saw 169
Guides, care of elevator 118
Hammer tests of boilers 55
Hand-holes in boilers 23
Hand-lamps, portable 95
Hand-wheels, guarding of revolving 156
Headers, steam 56, 86
Heaters, feed-water 41
Hoists, guarding of 143
Hollow set-screws 135
Hospital room, emergency 160
Hydro-extractors 154
Hydrostatic tests of boilers 55
Ignorance 6
Incrustation in boilers 35
Inspections, boilers 46
  elevator cables 112
  flywheel 77
  governors 77
  machines 8, 160
  pulleys 142
  works 8, 160
Intoxicants 7
Introduction 1
Jointers, guarding of 175
Lamps, portable electric hand 95
Laying up a boiler 44
Lifting capacity of elevators 124
Lighting, insufficient 5
Locking-devices, elevator 107
Lock-nuts, elevator valve-stems 117
Low-water alarms 28
Lubricating devices, automatic 88
Lubrication of air-compressor cylinders 88
  elevator cylinders 118
Machinery, cleaning 131
  forbid use of broken or defective . . . 160
  guarding of 131
  overcrowding 5

Machinery, painting moving parts red 132
 paper-box 152
 position of 144
 roll-feed 150
Management and supervision of works 8
Man-holes in boilers 22
Material, boilers 15
Mechanical records, keeping of 160
Melting-pots 156
Mixing-machine, guarding of 157
Motors, guarding of 90
 oiling and cleaning 91
Naphtha, care in using 164
Oil, removal from boilers 40, 44
Oiling shafting 133
Omissions 57
Overcrowding machinery 5
Overwork 7
Paper-box machinery 152
Paper cutters, guarding of 156
Patches on boilers 54
Physical surroundings of workmen 5
Pipes, steam 56, 83
Piping, engine 83
 in general 83
Piston clearances 81
Piston-rods, examination of elevator 122
Planers, guarding of 175
Platforms, guarding of 53
Portable hand-lamps 95
Power cleaners 43
Precautions in entering boilers 45
Pressure tanks, equipment of 123
 examination of elevator 123
Printing presses, guarding of 156
Projecting set-screws 135
Pulleys, guarding of 131, 137
 inspection of 142
Pulverizers, guarding of 159
Pumps, air, guarding of 60
Purifiers, live-steam 42
Racing of engines 62, 69
Reducing-valves 57, 154

- Respirators . . . 156
- Rim-joints, engine flywheels, efficiency of . . . 62
- Rivet-holes in boilers . . . 19
- Riving knife for saws . . . 168
- Roll-feed machinery . . . 150
- Rotaries . . . 56
- Rubber mats . . . 91, 168
- Rubber mills, caution in . . . 157
- Rules, boiler-room . . . 47
  - do. additional . . . 50
  - for elevator operators . . . 127
  - for workmen . . . 8, 160
- Safe-lifting elevators . . . 110
- Safety devices, design of . . . 166
  - elevator . . . 105
    - do. care of . . . 106
  - failure to use when provided . . . 7
  - in general . . . 9
- Safety-stops, care of . . . 72
  - engine . . . 69, 72
  - some home-made . . . 74
- Safety-valves of boilers . . . 25
- Saws, guarding of band . . . 173
  - guarding of circular . . . 168, 169
  - guarding of cross-cutting . . . 173
  - guarding of swing . . . 173
- Scale in boilers . . . 35
- Seams, boiler . . . 16, 24
  - calking . . . 25
  - exposure to fire . . . 24
- Separators, steam . . . 82
- Set-screws, projecting . . . 135
  - protected . . . 135
- Shaft couplings . . . 136
- Shafting, guarding of . . . 131
  - oiling . . . 133
- Shapers, guarding of wood . . . 182
- Sheaves, fastening and care of, elevator . . . 116
  - sizes for elevator cables . . . 116
- Shock, electric . . . 96
- Signs, useful, for elevators . . . 130
  - do. in factories . . . 167
  - do. in wood-working shops . . . 185

Stairways 155
Stay-bolts in boilers 25
Steam-gauges 30
  pipes 56, 83
  separators 82
  traps 83, 85
Stokers, guarding of 53
Stop-motions, automatic elevator 118
Stops, some simple governor 69
Stop-valves, boilers 26
Storage of heavy objects 159
Supervision and management of works 8
Surface blow-off 32
Surroundings, physical 5
Swing saws, guarding of 173
Switchboards 91
Switches 91
Tests, boiler 55
Tools, loose handles on 155
Transformers 93
Traps, steam 83, 85
Tubes, cleaners 43
  expanders 20
  setting 20
Type-casting machines 156
Vacuum-breakers, automatic 77
Valves, automatic boiler cut-off 27
  "pilot" 26
  reducing 57, 154
  relief 83
  safety 25
  stop 26
Vats, guarding of 155
Ventilation 7
Water-column connections 34
Wheelbarrow-handle knuckle-guard 157
Winches 142
Wire straighteners, guarding of 159
Wiring, electric 93
Wood shapers, guarding of 182
  working machines, miscellaneous 185

Steam Boiler Inspections

In the year 1908, the steam boiler inspectors of The Fidelity and Casualty Company made 59,463 visits of inspection, and made 37,094 internal inspections and 78,558 external inspections of the 33,975 boilers insured by it. In addition, they made 2,210 hydrostatic tests.

They discovered 13,214 defects, as follows:

Defective pressure-gauges	148
" settings	448
" riveting	262
" water-gauges	188
" and unprotected blow-off pipes	947
" feed-pipes	174
" heads	131
" patches	341
" safety-valves	214
" mud-drums	88
Overloaded safety-valves	198
Safety-valves of insufficient area	103
Stop-valves between boiler and safety-valves	19
Internal corrosion and pitting	1,171
External " " "	855
Cases of sediment and deposit	897
" " scale and incrustation	1,872
Bracing insufficient	90
Broken and loose stays and braces	239
Furnaces out of shape	1,046
Burned plates	211
Blistered plates	159
Bagged plates	737
Cracked plates	390
Serious leakage at tube ends	875
" " at seams	431
Boilers without pressure-gauges	10
" " water-gauges	7
Unclassified defects	963
Total	13,214

Elevator Inspections

In the year 1908, the elevator inspectors of The Fidelity and Casualty Company made 29,724 visits of inspection, and made 35,917 inspections of the 7,759 elevators insured by it.

They discovered 6,915 defects, as follows:

Defective worm-shafts	113
“ cars	152
“ overhead work	96
“ guides and posts	100
“ guide-shoes and springs	158
“ safety-devices	243
“ operating-devices	176
“ governor-ropes	186
“ safety-governors	98
“ hand-cables	585
“ hand-chains	34
“ lifting-cables	684
“ lifting-chains	20
“ counter-weight-cables	757
“ and broken sheaves	89
“ gears (worm and square)	139
“ door-locks	576
“ enclosures	431
“ automatic-stops	176
“ magnet-brushes	36
“ electric-motors	17
“ insulation	51
“ commutators	51
“ rheostats	52
“ keys	41
“ machine-brakes	138
“ valve-racks and pinions	53
“ pumps	7
“ engines	54
“ cable-drums	57
“ cylinders and valves	122
“ piston-rods	83
“ belts	72
“ chain and cable connections	12
“ and leaking cylinders and valves	91
Unguarded approaches at landings	152
Missing clamps on lifting-rods of counter-weights	47
Machine not provided with proper facilities for examining worm and gear	6
Passenger elevators not provided with safety speed-governors and all their attachments	4
Counter-weight-cables not properly connected	45
Minor adjustments	911
Total	6,915

HOME OFFICE
THE FIDELITY AND CASUALTY COMPANY
92 TO 94 LIBERTY STREET AND
97 TO 103 CEDAR STREET, NEW YORK

SEMI-ANNUAL STATEMENT

THE FIDELITY AND CASUALTY COMPANY OF NEW YORK

JUNE 30th, 1909

ASSETS

Stocks and Bonds (Market Values of June 30, '09, Bid Prices)	**$6,730,864.18**
Real Estate	**983,300.28**
Cash in Banks and Office	**598,602.06**
Gross Premiums in course of collection (not overdue)	**1,020,707.43**
All other Assets	**45,853.09**
	$9,379,327.04

LIABILITIES

Reserve for Unearned Premiums			**$3,671,579.96**
Liability Losses	Claims resisted for policy-holders		**777,525.00**
	In process of adjustment		**100,825.00**
	Further Reserve under N. Y. Law of 1905		**180,613.90**
Steam Boiler Losses, in process of adjustment			**5,614.00**
All Other Losses, in process of adjustment			**600,133.24**
Commission on Premiums in course of collection			**286,549.17**
All other Liabilities			**184,752.49**
Capital Stock	**$1,000,000.00**	Surplus to Policy-holders	**3,571,734.28**
Net Surplus	**2,571,734.28**		
			$9,379,327.04

Amount of All Losses Paid to Date, June 30, 1909

$30,434,633.82

This Company Grants Insurances as Follows:

FIDELITY DEPARTMENT

gainst loss by defalcations of persons in positions of trust.

ACCIDENT DEPARTMENT

PERSONAL ACCIDENT. Against death and loss of time caused by accidental bodily injuries.

HEALTH. Against loss of time caused by sickness.

PLATE-GLASS DEPARTMENT

gainst loss by accidental breakages.

LIABILITY DEPARTMENT

EMPLOYERS' LIABILITY. Against damages for personal injuries sustained by employees of manufacturers, miners, contractors, etc.

EMPLOYERS' PUBLIC LIABILITY. Against damages for personal injuries sustained by persons other than employees through industrial operations.

TEAMS. Against damages for personal injuries caused by horses and vehicles.

WORKMEN'S COLLECTIVE. Collective personal accident insurance for workmen in industrial establishments.

PHYSICIANS' AND DRUGGISTS' LIABILITY. Against damages claimed by patients or customers.

OWNERS' AND LANDLORDS' LIABILITY. Against damages for personal injuries sustained by persons on their premises.

PASSENGER ELEVATORS. Against damages for personal injuries sustained by passengers.

BOILER AND FLYWHEEL DEPARTMENT

STEAM BOILER. Against, 1st, the direct loss of property; 2d, damages for property of others destroyed; 3d, damages for personal injuries: caused by explosion of steam boilers.

FLYWHEEL. Against, 1st, the direct loss of property; 2d, damages for property of others destroyed; 3d, damages for personal injuries: caused by disruption or explosion of flywheels.

BURGLARY DEPARTMENT

or bankers, merchants, householders and others against loss by burglary.

THE COMPANY, IN ITS FIDELITY, BOILER, ELEVATOR, AND FLYWHEEL DEPARTMENTS, EMPLOYS SKILLED INSPECTORS, MAKES THOROUGHGOING INSPECTIONS, AND REPORTS THEREUPON TO THE ASSURED

SEMPER
UBIQUE
FIDELITY
ACCIDENT
PLATE GLASS
LIABILITY
BOILER
FLY WHEEL

AUG 1 4 1930